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Introduction of the Carman Lecturer

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LADIES AND GENTLEMEN: For many years the Radiological Society of North America has set aside an evening at each annual meeting known as Carman Night, in memory of one of the greatest radiologists of all time, Russell D. Carman.

It is particularly gratifying to me to have been given the privilege of presiding at this meeting, since Russell Carman was one of my most intimate friends. I trust that it will not be thought amiss for me to express my great appreciation for his friendship and to mention briefly one of his outstanding accomplishments in the field of Radiology.

Carman's greatest interest in the specialty of Radiology lay in the roentgen study of the gastro-intestinal tract. Before becoming associated with the Mayo Clinic, he had attracted attention for his accurate diagnosis of gastro-intestinal lesions, and it was largely upon this work that his appointment as head of the Department of Radiology of that institution was based. His uncanny accuracy in the diagnosis of lesions of the digestive tract, which gave him world fame, was the result of hard work and careful attention to small details. It is reported that in a large series of peptic ulcer cases which subsequently came to operation his diagnosis was confirmed in 98.21 per cent. This, as far as I know, has never been excelled or equaled.

It is a most unfortunate circumstance that in the very height of his career—at a time when, with his ripe experience and rare judgment, he could have been of the greatest assistance to organized Radiology—he was stricken with an incurable malady.

The Radiological Society honors itself in honoring this great radiologist. As a tribute to his memory it invites, after great care and deliberation, an outstanding figure in Radiology to lecture on some radiological subject on the occasion of each annual meeting.

We are most fortunate in having as this year's Carman lecturer the head of the Department of Radiology of the University of Pennsylvania, whose subject is "Excretory Urography as a Test of Urinary Tract Function," Dr. Eugene P. Pendergrass, or as he is known to all of us, "Gene."

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EUGENE P. PENDERGRASS, M.D.

Carman Lecturer, 1942

Excretory Urography as a Test of Urinary Tract Function[1]

Carman Lecture

EUGENE P. PENDERGRASS, M.D.

Philadelphia, Penna.

Mr. President and members of the Radiological Society of North America, I want to assure you that we at the University of Pennsylvania are deeply grateful for the honor to one of its clinics which is implied in the invitation to deliver the ninth Carman Lecture. The obligations which acceptance entails are heavy, particularly so in the present instance, inasmuch as the standard set by the previous lecturers has been exemplary.

This lectureship (23) was inaugurated at the Twentieth Meeting of the Radiological Society in memory of Russell Daniel Carman, for his extraordinary ability, his great service to radiology, and his loyal devotion to this Society. It will be stimulating to review briefly Doctor Carman's fruitful career for the benefit of those who had not the privilege of knowing him.

Russell Daniel Carman (21), master roentgenologist and one of the founders of this Society, was born at Iroquois, Ontario, March 18, 1876. His preliminary education was obtained at Minneapolis Academy, after which he spent two years in medicine at the University of Minneapolis. He completed his course at Marion-Sims College of Medicine, St. Louis, receiving his degree in 1901. There followed a year of graduate work at Johns Hopkins Medical School, from which Doctor Carman returned to St. Louis to practise. His first intention was to take up orthopedics, but he was soon attracted to medical roentgenology. His aptitude in this field was recognized very early by his election to the professorship of roentgenology in St. Louis University. From this he resigned to accept a similar position in Washington University. In 1913, Doctor Carman joined the staff of the Mayo Clinic as head of the Section on Roentgenology and continued in that capacity until his death in 1926.

In a period of less than a quarter of a century Doctor Carman published at least 80 scientific articles embracing many fields in which roentgen diagnosis is employed. Possibly his greatest single contribution to radiology had to do with his skill as a fluoroscopist and the published observations thereof. More than any other man, he contributed toward bringing the roentgenologic examination of the digestive tract into general use (21). His book *The Roentgen Diagnosis of Diseases of the Alimentary Canal*, is an authoritative source of information for any interested in that subject.

It was my privilege to know Doctor Carman, and it is with joy that I recall some of his clinical visits to Philadelphia, when he stayed at the home of my mentor, the late Dr. Henry K. Pancoast. On one such occasion, I was impressed with the relatively small amount of time that Doctor Carman spent in the larger radiologic departments in Philadelphia. When I asked the reason for this, Doctor Carman told me that, in visiting radiologists who could not afford to purchase modern equipment, he frequently learned of many ingenious devices and methods of studying patients, some of which were important contributions. I have no doubt that Russell Carman in this, yet another way, did a great deal to stimulate better work in radiology.

Anyone who has had an opportunity to

[1] From the Radiological Clinic of the Hospital of the University of Pennsylvania, Philadelphia, Penna. Presented before the Radiological Society of North America, at the Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30–Dec. 4, 1942.

visit California and to see its "big trees" is inspired by them. There are none like the giant sequoias. They are the largest and oldest of living things (12). "Their straight, upright position seems to hold them to the ground (12)." It is greatly to their advantage that they are found in groves, placed in a dense forest of other conifers, which aid in maintaining these giants in their upright and lofty position. For me, a serious lesson to be learned from the "big trees" is that, as with them, we in radiology should sow and cultivate a more intimate collaboration with our clinical colleagues to the end that our understanding of, and contribution to, medical radiology will be great. Russell Carman was a human example of a "big tree." We need only to refer to his writings to be impressed with this.

The subject chosen for this evening is one that illustrates how essential is close collaboration in providing for the patient the maximal amount of information. Unless we are prepared to seek out and use to the fullest extent the clinical knowledge of our colleagues, much valuable information afforded by urographic studies may be missed and we may approach the state of simple roentgenologic technicians.

As an *introduction* to this immense subject let us review some essential *anatomic* and *physiologic* data.

The *kidney* should be considered a filter plant, which not only removes from the plasma the protein metabolic waste and foreign substances, but also makes continual adjustments in the vital constituents of the plasma (13).

Each adult human kidney contains an average of about 1,283,000 functional units known as *nephrons* (22). The nephron (Fig. 1) consists of a *glomerulus* and a subjoined *tubule*, the latter being divided into three major segments; a proximal, which immediately adjoins the glomerulus and has the largest diameter; an intermediate of smaller diameter; a distal segment (30).

The nephrons are grouped into a dozen major divisions, the pyramids, and these into groups which discharge through a common orifice into the renal pelvis, thence into the ureter and bladder (28). Those subdivisions in turn are further divisible into "structural units," roughly pyramidal blocks, each consisting of about one hundred fifty tubules together with their malpighian bodies and blood vessels (28).

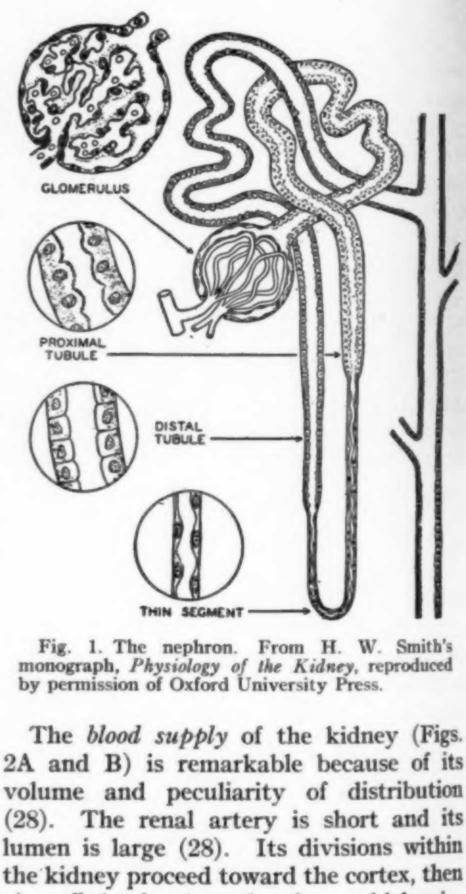

Fig. 1. The nephron. From H. W. Smith's monograph, *Physiology of the Kidney*, reproduced by permission of Oxford University Press.

The *blood supply* of the kidney (Figs. 2A and B) is remarkable because of its volume and peculiarity of distribution (28). The renal artery is short and its lumen is large (28). Its divisions within the kidney proceed toward the cortex, then give off the fine branches from which arise short terminal twigs (afferent arterioles, that supply the glomerular capillaries enclosed within the malpighian bodies (28). The emergent afferent vessels (about one-half the diameter of the efferent) divide into a profusion of capillaries which are distributed to the tubules (13). In some instances the blood supply of a

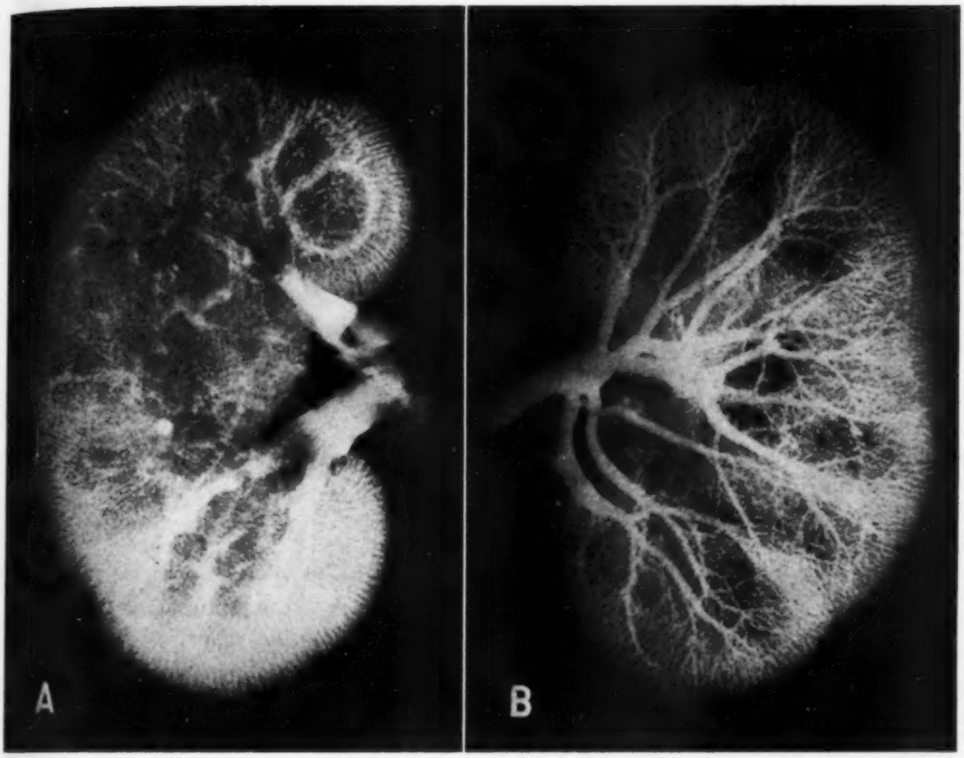

Fig. 2. A. Right kidney of white male, age 37 years, with roentgen opaque mass injection of the renal veins. The larger vessels are not so completely filled as in the arterial injection of the opposite kidney (2B). Injections were made at two points. The vessels were of approximately the same degree of minuteness as found in the arterial tree.

B. Left kidney with roentgen opaque mass injection of the arterial tree from one point (same patient as Fig. 2A). The mass was of a moderate degree of minuteness which was stopped short of the capillary arborization. (These specimens were prepared by Dr. Oscar Batson, Professor of Anatomy, University of Pennsylvania.)

tubule is not derived, even in part, from the glomerulus of the same nephron but from elsewhere (13).

The *nerve supply* of the kidney receives very little consideration in most books on physiology. Nerves do not seem to be essential for urine formation, since the denervated (17) or reimplanted (27) kidney apparently functions quite normally. The influence of nerves on urine formation appears to be produced entirely through their vascular effects (13). In the formation and elaboration of normal urine in higher animals and man the work of excretion is largely, if not wholly, performed by the heart through the medium of the kidney by maintenance of adequate glomerular circulation (28).

RENAL PHYSIOLOGY ON WHICH FUNCTION TESTS ARE BASED

In the last 20 years great progress has been made in our knowledge of the physiology of the kidney. The modern theory of renal function, evolved from work in the laboratories of Richards (28), Marshall (20), Smith (30), Shannon (29), Van Slyke (32), and others, is that as the blood courses through the glomerular capillaries a part of the plasma water is mechanically filtered out into the capsular spaces of the glomeruli. The glomerular fluid is identical with that secured by filtering plasma through a collodion membrane. All of the solutes of the plasma are in it, not only those, such as urea and uric acid, which are waste products, but

also the glucose and bicarbonate vital to or required by the body (32). Other substances, such as water and salt of the filtrate, are passed in much greater amounts than the body can afford to lose (32). To let the waste products pass and at the same time recover the substances in the body, the cells lining the tubules exert a highly selective action in reabsorbing the physiological materials (32).

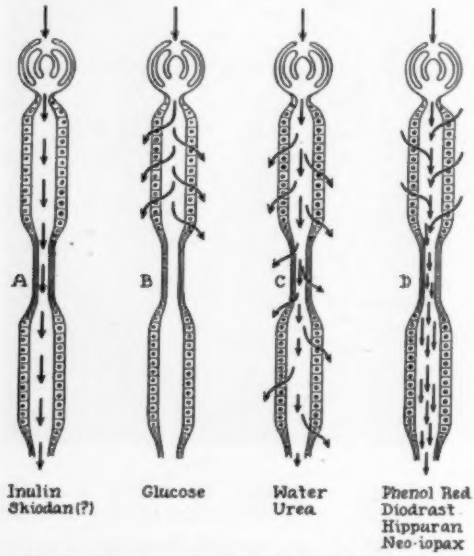

Fig. 3. Diagram of some of the substances elaborated by the kidney (modified from Smith: *Studies in the Physiology of the Kidney*).

Besides their power of selective reabsorption, the tubules have a reserve function of excretion of foreign substances, such as injected dyes (32). This function appears to have no important part in man in the excretion of naturally occurring urinary substances; it is a reserve power used to handle foreign substances that cannot be excreted by means of glomerular filtration (32).

The formation of urine, therefore, is the result of three processes: filtration in the glomeruli, reabsorption and excretion in the tubules. As an illustration, the course of certain substances elaborated by the kidney may be outlined as follows (see also Fig. 3):

Water: Filtered in the glomeruli and reabsorbed in part in the tubules (30).
Inulin: Filtered in the glomeruli (30).
Glucose: Filtered in the glomeruli and reabsorbed entirely in the tubules (30).
Urea: Filtered in the glomeruli and partially reabsorbed by the tubules (30).
Phenol red: Filtered in the glomeruli and excreted in the tubules (30).
Diodrast: Filtered in the glomeruli and excreted in the tubules (9, 30).
Skiodan: Filtered in the glomeruli (9, 18).
Hippuran: Filtered in the glomeruli and excreted by the tubules (9, 18).
Neo-iopax: Filtered in the glomeruli and excreted by the tubules (31).

KIDNEY FUNCTION TESTS

In order to understand kidney function tests and evaluate, in functional terms, the urographic findings, it is necessary to grasp the modern theory of kidney physiology. Drury (7), in considering this subject, writes as follows: "The new kidney function tests have all made use of a very general principle which applies to a great number of substances excreted by the kidney. This law for any given individual states that the amount of substance excreted in the urine in a given time is directly proportional to the concentration of that substance in the blood during the time of excretion.

"The term 'clearance' has come into popular use in connection with kidney function tests. The phenol red clearance may be taken as a typical test of this sort. The blood plasma of the arterial blood containing phenol red flows through the kidney at a rate of some 500 c.c. per minute. A good part of this is taken out by the kidney and excreted in the urine. The plasma of the venous blood flowing from the kidney consequently contains much less phenol red than the arterial."

It is possible, therefore, to determine, by simple procedures, the phenol red clearance (7). There is evidence that inulin

(30) is excreted only by the filtration process of the glomeruli and is not reabsorbed in the tubules. Hence inulin clearance represents the actual volume of the glomerular fluid.

"As shown in Table I," Drury continues, "the urea clearance is less than that of inulin. We know that both substances

TABLE I: CLEARANCE OF VARIOUS SUBSTANCES IN THE URINE (DRURY)

Urea	75 c.c. per minute
Inulin	120 " " "
Creatinine	170 " " "
Phenol red	400 " " "
Hippuran	600 " " "
Diodrast	600 " " "

pass through the glomerulus in the same concentration as they are in the plasma, and if less urea in comparison with inulin is filtered into the urine we are forced to assume that some of the urea is reabsorbed in the tubules" (7). On the other hand, substances having higher clearances, such as diodrast, must be elaborated not only by glomerular filtration but also by tubular excretion. To illustrate, suppose three substances—urea, inulin, and diodrast—are present in plasma in concentrations of 1 mg. per c.c. It would be necessary to have 120 mg. of inulin in the urine, since inulin can reach the urine only by way of filtration. The 120 c.c. of plasma would also contain 120 mg. of urea and 600 mg. of diodrast. Forty-five mg. of urea must have been reabsorbed by the tubules and a considerable amount of diodrast has been added to the urine by excretion from the tubules.

Thus, in the new kidney function tests, attention is directed toward measuring the function of the two parts of the kidney unit, the glomerulus and the tubule. Drury (7) reminds us that the theory is recent, and needs seasoning and strengthening with additional work before we can rely entirely on it.

ROENTGEN CONSIDERATIONS[2]

Anyone interested in this subject cannot but be impressed by the paucity of publications concerned with correlating urographic studies (3, 16) of various conditions with those of the clinician. This is true in spite of the fact that in many places there is organized *clinical* investigation of the urinary tract and the conditions that may influence it. There are those who believe that with urography one has a method by which it is possible to analyze the function and morphology of the urinary system. There are others who do not employ the procedure because they have been unsuccessful in its use. Not long ago a great many lesions in the gastro-intestinal tract went undetected because of our failure to study carefully the physiology of that system. Though there are many clinical methods available for detection of gallbladder and gastro-intestinal lesions, very few good clinicians would be satisfied with their evaluation of a patient without adequate roentgenologic studies of those structures.

In searching for the roentgen evidence of the physiological manifestations of the urinary tract, I have found it much more difficult than that experienced in a similar study of the gastro-intestinal system. I can tell you, however, that the knowledge obtained is just as fascinating. In a school that has been conscious of the fundamental investigations of Richards (28) and his excellent co-workers, it has been easy to seek an answer to some of our problems. Likewise, it has been our good fortune to have a close and friendly collaboration between the clinical and radiological departments. For years we have assembled once a week with our urologists to discuss all the urographic material, the current urological cases and problems. That conference has enabled us to render better opinions and neither department would wish to abandon it. That such collaboration is too rarely operative elsewhere seems manifest upon reading urologic publications or listening to the complaints of urologists and radiologists as to the difficul-

[2] May I interject a remark here for the appeasement of our purist friends? The word "shadow," denoting the actual thing seen on a roentgenogram, has been eliminated consciously to avoid a ponderous and impractical style. Surely all of us realize that we are viewing shadows and not truly seeing organs.

ties and lack of co-operation. If this observation is accurate, it is my reasoned judgment that if an improved *esprit de corps* is encouraged among those interested in urological problems, not only will the prerogative of the consultants seem less important and teamwork be developed, but the studies will become more interesting, more credit will accrue to the physicians, and, most important, patients will benefit from the wisdom of a group rather than from that of several individuals.

The time has passed when it is excusable for the physician, surgeon, urologist, or radiologist to become over-confident about his individual ability to detect small morphological changes in roentgenograms. That is but a part of the problem. Teamwork offers the solution, a state of free interchange of ideas and correlation of every man's data.

The physician or surgeon requests urography usually as an aid in the recognition of anatomico-pathological deformities of the urinary tract rather than as a measure of urinary tract function. Doubtless most clinicians believe that the common function tests give them all necessary information except for differential renal function.

In surgery, an established procedure is to determine the patient's cardiac, renal, and pulmonary reserve (11). Fishberg (11) states that in the urologic patient, kidney function is of special significance, because practically all therapy is aimed directly or indirectly at the prevention of damage to, or preservation of, kidney function. From a surgical point of view, the function of the glomerular component and its reserve is of greater importance than that of the tubular component (11). If there is no filtration, there is no urine formed. It is stated that the clinical syndrome of uremia is the result of suppression of glomerular filtration, and may take place in the presence of fair or even good tubular function (11). It seems obvious, however, that an estimation of kidney function must include an evaluation of the tubular as well as the glomerular components.

Roentgen Technic: The roentgen technic can be planned better if all clinical data be available at the time of the urographic examination. Since this is obviously impossible in many instances, one must provide a technic that will give information concerning size, position, contour, disturbance in the clearance of the contrast medium, the elasticity and mobility of the structures, and a "knowledge of the motor or transport mechanism of urine flow" (6).

The urographic study that is operative in our clinic at this time includes the following:

Preparation of the Patient: We (26) have prepared a form outline, reproduced here, to record preliminary data on the prospective patient. I believe that the physician who injects the contrast medium should be responsible for obtaining this information. At present we use the intradermal test for sensitivity to the compound and this test is made the day before the contemplated examination.

No unusual preparation of the abdomen is planned unless the intestines contain considerable gas. If the patient is used to taking a laxative, it may be ordered. Very little fluid is allowed after the evening meal on the day prior to the examination. A light breakfast with a small amount of fluid may be taken on the morning of the examination, without producing too much intestinal gas in most instances.

The Contrast Medium: It is advisable to give sufficient contrast medium. An individual weighing 200 pounds should receive more of the contrast medium than one who weighs 100 pounds. Findley (10) and his co-workers state that 1 c.c. of diodrast per 4.4 pounds of body weight is the minimal amount necessary to maintain the plasma iodine concentration above 15 mg. per cent for thirty minutes, and that tubular excretion of diodrast functions only above that level. The technic employed by us, at present, provides that when administering diodrast, 35 per cent solution, 1 gram be used per 12.57 pounds of body weight (1 c.c. per 4.4 pounds of

PRELIMINARY DATA IN USE OF CONTRAST MEDIUM

File No.____________ Age____________

Name____________ Male / Female Date____________

Clinical Diagnosis____________

Reasons for which Urogram was Requested____________

____

Contrast medium to be used____________

1. Personal History of Asthma____________ Hay Fever____________

   Rose Colds____________ Excessive Sneezing____________ Hives____________

   Food Rashes____________ Eczema____________ Sick Headaches____________

   Drug Reactions____________

   Any Previous Iodine Medication____________

   Previous Urogram-When____________ Dye Used____________ Reaction____________

2. Family History of each of above (including siblings, parents, aunts, uncles, grandparents)____________

   ____

3. Patch Test Date____________ Result____________
4. Intradermal Test Date____________ Result____________
5. Mouth Test Date____________ Result____________

Immediate allergic reactions to injection

Flushing____________ Nausea____________

Urticaria____________ Vomiting____________

Edema____________ Fainting____________

Asthma____________ Pain in shoulder____________

Venospasm____________ Sense of constriction in neck____________

Any others____________

Delayed reactions to the contrast medium (date and interval)____________

____

____

____
Radiologist

body weight); with skiodan, 40 per cent solution, 1 gram per 7.5 pounds is used (1 c.c. per 3 pounds of body weight). In practice, excellent urograms may be obtained with a 20 c.c. dose of diodrast, 35 per cent solution, in persons weighing less than 132 pounds, whereas 30 c.c. should be used in heavier patients.

For patients giving a history of allergy, epinephrine solution 1:1000, in a dose of from 0.2 to 0.5 c.c., is offered as a prophylactic measure immediately before

starting an injection of the contrast medium. This, we feel, gives added protection against allergic reaction.

We have easily available in each room where the urographic study is made, a tray containing the following materials with which to combat a reaction: a 1 c.c. syringe, hypodermic needle No. 19, intravenous needle No. 20, 3-inch intracardiac needle, tourniquet, hemostat, nasal catheter, airway, ampoule file, rubber-capped bottle of epinephrine, rubber-capped bottle of atropine sulphate, an ampoule of caffeine sodiobenzoate, and an ampoule of calcium gluconate.

A physician should administer contrast medium and should remain with the patient during the procedure of urography or be available on a moment's notice.

The use of pitressin to eliminate gas in these persons carries potential danger (26).

Plan of Study: The roentgenograms are planned as follows:

1. A survey of the abdomen, in the supine position, before the contrast medium is injected;
2. At 5 minutes after the completion of the injection, in the supine position;
3. At 15 minutes in the inverted position (25–35 degrees);
4. In the prone position;
5. In the erect position;
6. In the left oblique;
7. In the right oblique;
8. In supine position at 30–45 minutes.

It may be necessary to make additional exposures to show particular structures, or multiple exposures or kymograms to demonstrate peristaltic waves; or the examination may be prolonged in order to demonstrate delayed clearance or obtain better nephrograms.

In explaining the difficulties with urography, Baker (2), lists the following:

1. Films are sometimes exposed when certain components of the urinary tract are in systole and at other times when they are in diastole;
2. The urinary tract, because of reflex disturbances, either renal or extrarenal, may fail to function on one or both sides;
3. Rapid excretion of the contrast medium;
4. Errors in roentgen technic;
5. Errors in interpretation.

To these may be added faulty preparation of the patient and insufficient dosage of the contrast medium. One of the most annoying features is the presence of gas in the intestinal tract. If the patient has pain and has taken sedative drugs, it may be impossible to get rid of the intestinal gas until the effect of the drug wears off. Errors in interpretation may occur because of the unidirectional projection of the shadows, distortion, rotation, overlapping, lack of sharpness, effect of respiration, and variation in the type of dye shadow resulting from peristalsis and other factors concerned in transportation of the urine (16). Many of these disturbing appearances can be obviated if exposures are made in several positions.

In patients having urographic studies the following information should be sought:

1. *Gross anatomy of kidneys*
   (*a*) Position, size, shape, and axis of the kidneys.
   (*b*) Density of the kidney shadow.
2. *Roentgenologic quality of clearance by contrast media*
   (*a*) Selection of contrast medium. Decide if it is wished to test tubular or glomerular function or both.
   (*b*) Comparison of clearance from both kidneys.
   (*c*) Compare urea clearance and the urographic findings after skiodan.
   (*d*) Determine how long the urographic examination should be carried beyond the conventional time.
3. *Anatomy of renal pelvis*
   (*a*) Character of filling.
   (*b*) Pelvis, intrarenal or extrarenal.
   (*c*) Relative proportion of the medulla and cortex.
4. *Function of the renal pelvis in transportation of urine*
   (*a*) Character of peristalsis.
   (*b*) Elasticity of the pelvic structures and reversibility of any dysfunction.
   (*c*) Disturbance in emptying.
5. *Ureters*
   (*a*) Presence and position of dye.
   (*b*) Quality of peristalsis.
   (*c*) Nature of dye transportation.

6. *Bladder*
   (*a*) Presence of dye in the bladder.
   (*b*) Appearance time and density.
   (*c*) Size of bladder.
   (*d*) Deformity.
   (*e*) Presence of lesion and its effect on the upper urinary tract.
   (*f*) Emptying of bladder.

There are probably many other points that the radiologist should consider while making these studies, but it is my belief that careful study of those outlined above will aid greatly in planning the roentgenologic technic to determine the function of the urinary tract.

GROSS ANATOMY OF THE KIDNEYS

In most adults we are able to see the renal parenchyma by virtue of the differential density of the kidney substance and the perirenal fat. In children and in very thin adults the renal tissue is much less conspicuous. Often the superior pole of the kidney is obscured while the lower two-thirds of the organ can be identified easily. On the anteroposterior roentgenogram, with the patient in the supine position the kidneys usually appear as two bean-shaped or oval masses lying obliquely in the paravertebral region of the upper abdomen. The right kidney is frequently the lower and the more mesial. The upper pole of the left kidney may be superimposed on the shadow of the posterior portion of the eleventh rib; while that of the right is partly obscured by the shadow of the twelfth rib. In females and older subjects, or in persons with relaxed abdominal musculature, the position of both kidneys is often lower. This also is true after forced inspiration. In many normals the long renal axis is parallel to the ileopsoas muscle. In hypersthenic persons the lower pole is more lateral so that the long axis is more transverse. In the asthenic the long axis may be vertical. The size of the normal kidney varies with a great many factors, and accurate measurements probably are of no consequence. *Gray's Anatomy*, however, gives the length as about 11 cm. and the width as 5 to 7 cm. Allowing for roentgenographic distortion, these figures become 13 cm. and 6 to 8 cm., respectively.

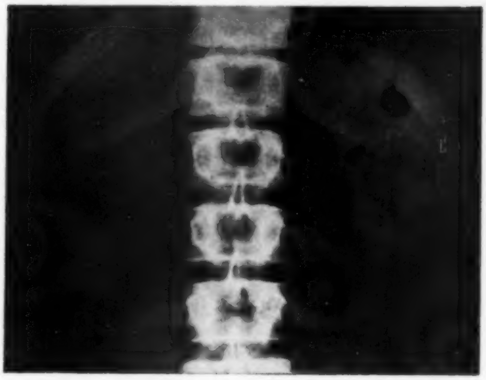

Fig. 4. Nephrogram at twenty-five minutes, due to non-opaque stone in the left ureter. The left kidney shadow is much denser than the right. Very little diodrast is seen in the right kidney.

In the lateral roentgenogram the kidneys cannot be identified except by their relation to the dye-filled pelvis and calices. They lie partially obscured by the vertebral bodies. The one farther from the film usually is anterior to the one close to the film.

In the erect posture there is usually a certain amount of ptosis. This varies greatly in different persons. It is often more on the right than on the left. Shortening of the long axis of the kidney due to rotation is frequently observed in the more severe degrees of ptosis. Bony landmarks, such as the transverse processes of the vertebrae, may be used to measure the range of the kidney.

As viewed on the anteroposterior roentgenogram the right kidney is bounded by the right lobe of the liver above, the ileopsoas muscle mesially and inferiorly, the hepatic flexure of the colon and the descending duodenum ventrally. The left kidney is bounded by the stomach above and mesially, the spleen above and laterally, the ileopsoas muscle mesially and inferiorly, and the pancreas and splenic flexure of the colon ventrally. Occasionally one can identify the shadow of the quadratus lumborum muscle crossing the lower pole of the kidney.

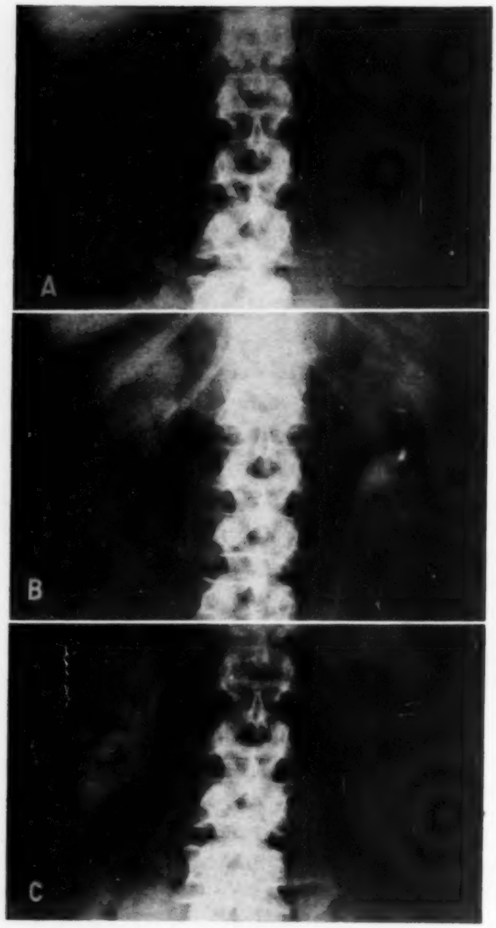

Fig. 5. Obstructive uropathy on the right side due to carcinoma of the cervix.

A. The right kidney shadow is denser than the left before injection of diodrast. This has been observed in instances where technical factors do not seem to be the explanation.

B. Same case as Fig. 5A, fifteen minutes after injection of diodrast. The left kidney pelvis and calices are outlined by the dye. On the right side the kidney shadow has become denser (nephrogram).

C. Same case at one hour. The calices and pelvis of the right kidney are dilated. The kidney parenchyma is still quite dense. Very little dye is seen in the pelvis and calices of the left kidney.

The density of the kidney shadows after the injection of a contrast medium is slightly increased over that found before the dye is administered. The explanation for the increased density is due to the contrast medium in the blood vessels and tubules of the kidney (33). If there is increased infraglomerular pressure, the kidney shadow gradually increases in density on the affected side, due largely to the iodine compound in the tubules (33), and one may observe a good example of a nephrogram, except in those instances where there is advanced kidney disease (Fig. 4). Occasionally one sees shadows of the kidney that are quite dense even before the contrast medium is injected (Figs. 5A, B, and C).

Fig. 6. Body section roentgenogram through the mid-portion of the left kidney twenty minutes after the administration of the dye. The kidney outline is shown to good advantage.

Body section roentgenograms of the kidneys after the injection of a contrast medium may reveal changes that cannot be seen in the conventional examination (Figs. 6, 7A and B).

ROENTGENOLOGIC QUALITY OF CLEARANCE OF THE CONTRAST MEDIUM

The term "clearance" has been defined as "the volume per minute of plasma

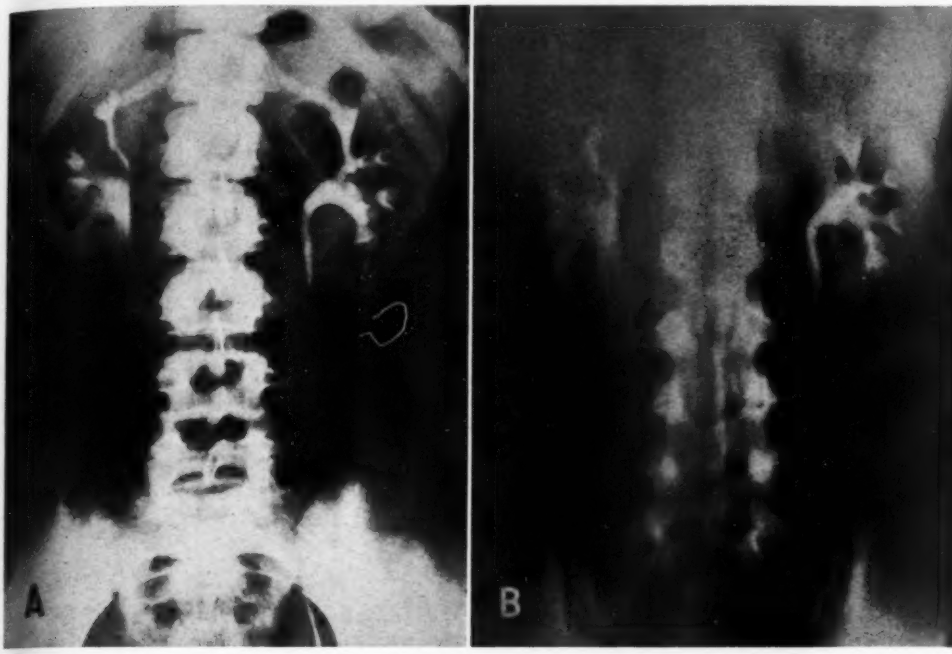

Fig. 7. A. Conventional examination of the urinary tract after the injection of diodrast.
B. Body section roentgenogram directed through the pelvis of the left kidney.

cleared of a given substance by the kidney or, more correctly, the volume of plasma which would be required to provide the amount of substance excreted per minute" (13). In order that there be no misunderstanding, the term "clearance" (diodrast clearance) as used in this article is confined to the roentgen appearances of the dye in either the kidney pelves or bladder or both at stated intervals of time. For instance, if the diodrast shadow is quite dense in the kidney pelves and bladder at the five- to forty-five-minute interval, the interpretation might be as follows: The diodrast clearance as observed by urography is satisfactory (Figs. 8A and B). I have elected to use "clearance" for such an observation in order not to confuse the elaboration of the dye (which is only one phase of kidney function) with transportation of the urine from the kidney through the bladder. In general, it may be stated that if the clinical tests of kidney function are not abnormal, the diodrast and skiodan clearance, as determined by urography, is very satisfactory, but the selection of a contrast medium that will be elaborated largely by the tubules (diodrast, hippuran, neo-iopax) is preferable if there is clinical evidence of kidney disease (low urea clearance and elevated Addis count) (1) (Figs. 9A and B).

If there is very little or no evidence of clearance of the contrast medium in the conventional thirty- to forty-five-minute roentgenograms, our technic includes additional roentgenograms made at the one- and two-hour intervals. From these, there may be evidence of delayed clearance in the kidney tubules (33) (nephrogram), pelvis, or bladder.

Findley, Edwards, Clinton and White (10) state that intravenous urography can be converted into a satisfactory test of renal function, that normal subjects excrete approximately 45 per cent of the injected dose of diodrast compound in thirty minutes, and that reductions in the rates of iodine excretion are roughly proportional to variations in urea clearance.

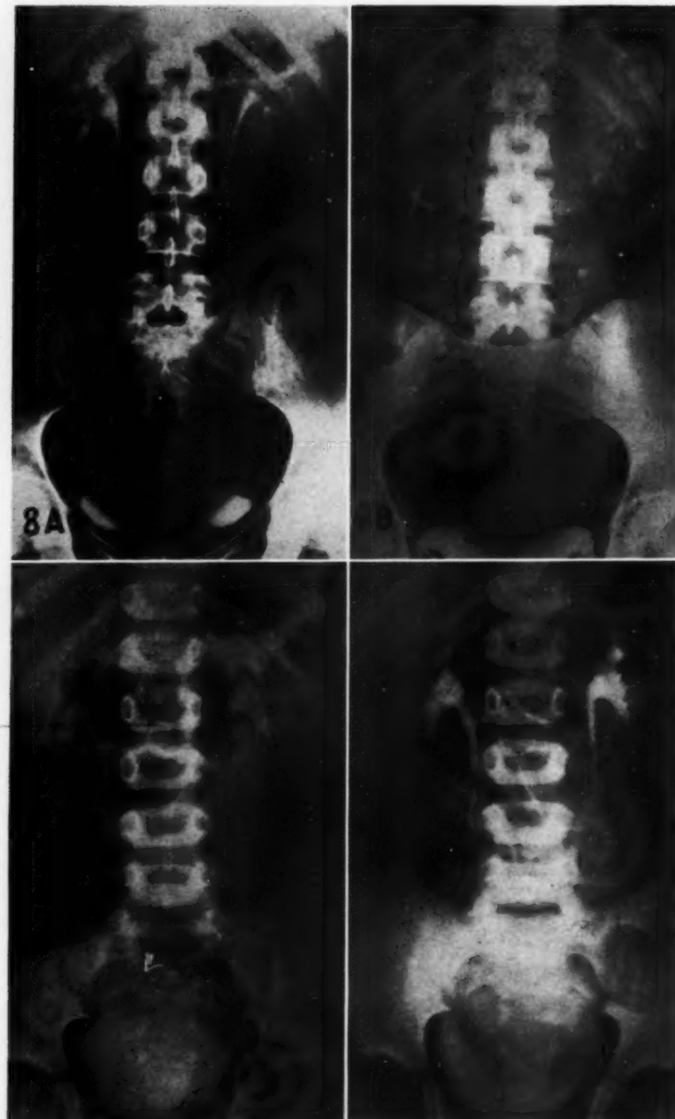

Fig. 8. A. Satisfactory "clearance" of diodrast. This examination was made in the inverted position. The dye shadow in the right kidney is quite dense and shows the calices and pelvis well. On the left side the calices contain very little dye. The bladder appears to be normal.

B. Same case with the urogram made in the erect posture. The pelves and calices have emptied very well, illustrating the lack of any disturbance in transportation.

Fig. 9. A. Disturbance of diodrast "clearance" as determined by the urographic examination in a patient who has glomerulonephritis. This urogram was made at twenty minutes after the injection. The shadow of the dye in the pelves and calices is much less than in the normal.

B. Urogram in the same patient two months later. The patient has improved considerably under treatment. The dye shadow in the calices and pelves is quite satisfactory, thereby illustrating the practicability of utilizing urography to demonstrate the variations in the elaboration of the dye in health and disease.

It is stated that glomerular filtration varies directly as the number of functioning glomeruli and inversely as the back pressure within Bowman's capsule (11). Any condition such as hypotension, shock, hemorrhage, dehydration, or cardiac failure will inhibit filtration by diminishing the mean pressure within the glomerular loop (11). Infraglomerular pressure obstruction, from whatever cause, will increase back pressure in Bowman's capsule and also inhibit filtration (11, 33). Fishberg states that destruction of kidney parenchyma, when partial (less than two-thirds), will not affect filtration, since the remaining glomeruli will hypertrophy and compensate. Bradford's (4) investigations on dogs show that if one third of the kidney weight is left, the animal remains in good health, the urine volume is increased, and the animal cannot concentrate the urine.

Addis (1) and Drury (7) report that a large dose of adrenalin given intravenously and pituitrin given subcutaneously reduced the urea clearance, and that the reduction was paralleled by a decreased blood flow. This observation may be of interest if adrenalin is given prior to intravenous urography.

Brown (5), observing the urea clearance, and Nice (25), reporting the urea clearance in normal pregnant women, found the clearance to be increased (Fig. 10).

In applying tests of renal function to the diseased kidney, one might consider that part of any impairment of function might be due not only to renal structural but, in addition, physiologic changes (15). In support of this observation is the work of Hayman (14), who, upon perfusing kidneys removed at autopsy, found that those showing evidence of benign arteriolar sclerosis and acute and chronic diffuse glomerular nephritis yielded less perfusate at various perfusion pressures than did normal kidneys. The kidneys showing only degenerative changes gave the same perfusate as the normal.

It may be apropos to speak again a word of caution concerning the use of contrast media (26). Contrast media have been used by us in instances when the urea clearance was as low as 10 per cent (Fig. 11). Just how safe the intravenous use of a contrast medium is under such circumstances is still questionable, but I believe that enough experience is available to permit the statement that, if there are no other modifying influences, one can do urography with safety on those whose urea clearance is not below 30 per cent and the Addis (1) count is not too high (Fig. 12).

Fig. 10. Urogram in a patient seven months pregnant. The "clearance" of diodrast is satisfactory and demonstrates the morphology of the calices, pelves, and ureters on both sides. There is some dilatation of those structures similar to that usually seen in pregnancy. The dilatation is more pronounced on the right side.

We have, on a number of occasions, employed both diodrast and skiodan in a patient who, because of kidney disease, has had a marked disturbance in the urea clearance, seeking to determine whether there was a difference in the density of the dye. In some we have found differences, skiodan, as a rule, creating less density than diodrast (Figs. 13A, B, and C). Although this and other observations in patients with kidney disease seem to support experimental observations that skiodan is filtered largely by the glomeruli

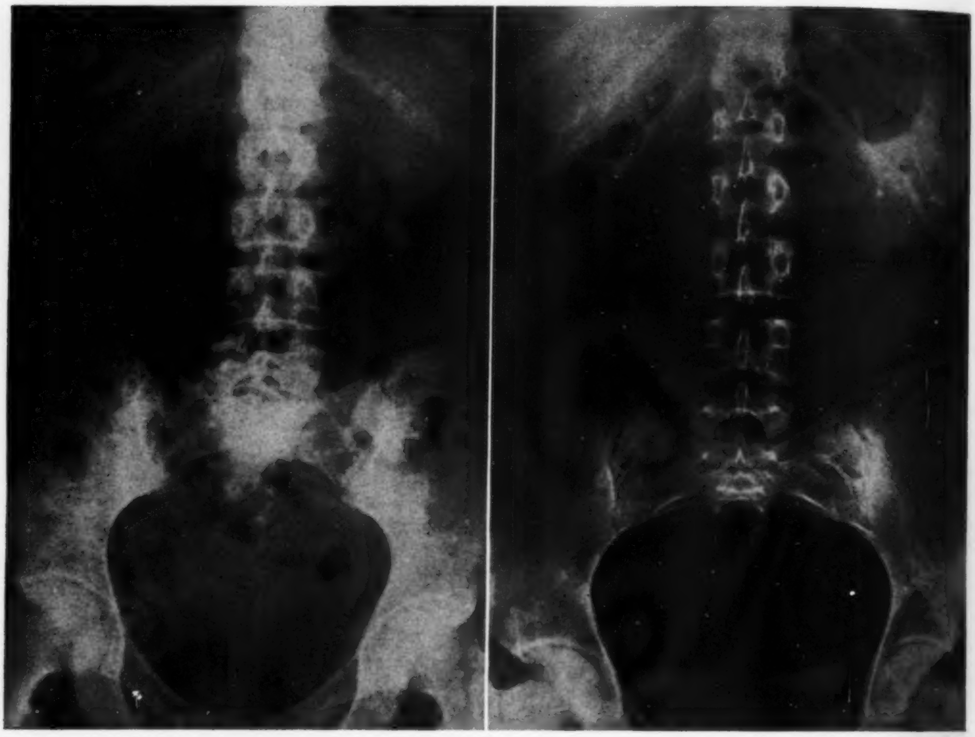

Fig. 11 (left). Urogram in a patient with chronic glomerulonephritis. The urea clearance was 10 per cent of normal. There is no roentgen evidence of diodrast clearance at one hour.
Fig. 12 (right). Urogram in a patient who has a urea clearance 26 per cent of normal. The dye shadow in the bladder is seen much better at one hour in this patient than in the one illustrated in Fig. 11. This patient has hypertension and the right kidney is considerably smaller than the left.

(9, 18) and diodrast excreted largely by the tubules (30), we do not believe that they are controlled sufficiently to be of any clinical significance. We do hope, however, to proceed with such observations as made by Findley and his co-workers (10) and not only to compare the physiological clearance of the contrast medium with that of urea, but in addition attempt to correlate the density of the dye in the urograms with chemical studies of the clearance in the urine.

ANATOMY OF RENAL PELVIS

The renal sinus which is located on the inner border of the kidney contains the renal pelvis and its calices, the blood vessels, nerves, and lymphatics of the kidney. The remaining space of the renal sinus is filled by fat which is continuous with that enveloping the kidney and its vascular pedicle.

The types of renal pelvis may be classified as (*a*) ampullary and (*b*) bifid. The *ampullary* type consists of a pelvis proper and two or more major calices from which a variable number of minor calices arise (8). In the *bifid* type there is almost complete absence of a pelvis proper, due to the division of the ureter almost immediately into two major calices and these into a variable number of minor calices (8).

There are many variations of these two basic types, as well as transitions from one to the other. The pelvis on one side may be different from that of the other in the same person, thereby making comparisons more difficult.

In the *ampullary* type, in addition to a

Fig. 13. Male, age 32, with nephritis and gout. The urea clearance was 10 per cent of normal, the blood urea acid 6 mg./100 c.c. and the B.U.N. 45 mg./100 c.c.

A. The urogram made at one hour fifteen minutes, with diodrast, shows a fairly good dye shadow in the bladder only. Examination done on 2/17/42.

B. Urogram in same patient after intravenous injection of skiodan. The examination was made at one hour fifteen minutes. The dye shadow in the bladder is very poor. It would seem that the diodrast clearance was better than the skiodan. Examination 9/24/42.

C. Same patient 9/25/42. Urogram with diodrast again shows the bladder shadow to be approximately of the same density as in A. There is roentgen evidence of a difference in the elaboration of skiodan and diodrast in this patient.

superior and an inferior major calyx, a middle major calyx may arise directly from the pelvis or from the superior or inferior calyx (8). The dimensions of the major calices vary greatly (8).

The number of the minor calices varies from 4 to 12, the average being 8. Each minor calyx consists of a narrow neck or canal connecting it with the major calyx from which it arises and an expanded terminal portion or fornix with a cup-shaped depression to receive one of the papillae of the parenchyma (8). Occasionally a small calyx may arise directly from the fornix (8).

The ampullary pelves are subdivided into three types, according to their relation to the kidney shadow. (*a*). In the *intrarenal* type, the pelvis proper lies within the kidney shadow. (*b*) In the *combined intrarenal* and *extrarenal* type, the pelvis lies partly within and partly without the kidney shadow. (*c*) The *extrarenal* pelvis lies outside the major portion of the kidney shadow. Observations concerning these anatomic matters are of great value to the urologic surgeon.

The *bifid* type of pelvis is of importance because there are only two major calices with a relatively small intervening pelvis proper (8).

The walls of the renal pelvis and its calices consist of three layers, an epithelial lining, a muscular layer, and an outer fibrous layer (8). These are continuous with similar coats of the ureters (8). The muscle fibers are arranged in such a manner (longitudinal and circular) as to propel the contents of the minor calices toward the pelvis proper.

The average capacity of the adult renal pelvis is thought to be about 7.5 c.c., but it is not unusual to see variations of 3 to 10 c.c. (8).

If the renal pelvis is well filled, one will be able to determine the relative proportion of cortex to medulla (Fig. 14). This in-

Fig. 14. Urogram illustrating the medullary and cortical portions of the left kidney. If a line is drawn just distal to the tips of the calices, it is possible, in a single plane, to estimate the relative proportion of the kidney shadow that is occupied by the medulla and the cortex. In this illustration, the portion of kidney substance lying outside the interrupted line is the cortex.

This patient has a small calculus in the lower end of the ureter, causing a mild degree of obstruction, which allows one to see its position.

formation is complementary to that obtained by observing the size of the kidney. The medullary portion of the kidney corresponds closely to that contained within a curved line drawn just distal to the tips of the fornices of the minor calices, and the cortical portion is that lying between the line and the periphery of the kidney.

In order to demonstrate the many constituent parts of the renal pelvis, we expose films in the supine, prone, inverted, erect, and oblique positions. Films exposed in the prone position will demonstrate calices that are frequently not seen in roentgenograms made with the patient in the supine posture.

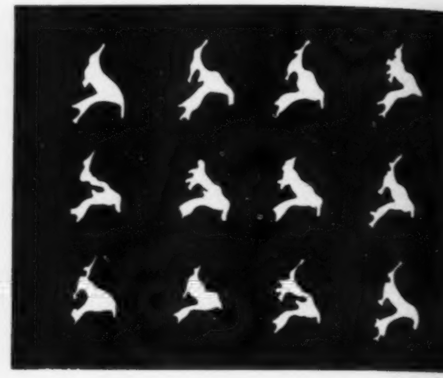

Fig. 15. Three cycles of peristalsis in the upper infundibulum. These illustrations are drawings prepared from original roentgenograms of a patient who had no anatomic pathology, but in whom there was failure of complete caliceal contractions due to residual infection. Permission to use this illustration was obtained from Dr. Jarre (16).

FUNCTION OF THE RENAL PELVIS IN TRANSPORTATION OF URINE

One of the valuable contributions to kidney physiology as observed by urography has been made by Jarre and Cumming (16), who, with the aid of the cinex-camera, portrayed and described what they believe represent the normal movements of the renal pelvis. They described a rhythmic, progressive, descending pro-peristalsis of the normal renal pelvis as demonstrated by rapid serial intravenous urograms. The peristalsis starts in the periphery and continues toward the ureter (Fig. 15). We have used kymograms after the intravenous injection of contrast medium to record peristaltic movements of the pelvis and calices. Although our kymographic records are for only a thirty-second period and our experience limited, our observations are similar to those of Jarre and Cumming (16).

Narath (24) has studied the anatomy of the calyx and directs attention again to the muscles which are concerned in its function (Fig. 16). On the basis of his anatomical and radiological observations following pyelography, he describes two phases of motion of the calices: (*a*) a collecting and (*b*) an emptying phase

Fig. 16. The calyx. 1. Musculus levator fornicis. 2. Fornix. 3. Musculus sphincter fornicis. 4. Musculus longitudinalis calicis. 5. Musculus sphincter calicis. 6. True pelvis. Permission for use of this illustration given by Dr. Narath (24).

(Fig. 17). The changes in the collecting phase are produced in accordance with the amount of urine elaborated (Fig. 18). As soon as the upper part of the calyx is filled, the sphincter calicis opens to let the urine flow into the pelvis. As soon as the emptying phase is completed, the collection phase begins. Narath (24) states that there is a close relation between the function of the sphincter calicis and the sphincter at the uretero-kidney pelvic junction, so that in the normal function of those structures no back pressure of urine is produced on the papillae.

Jarre and Cumming (16) believe that the filling of calices takes place rhythmically from the periphery under the milking action of the caliceal muscles on the pyramids. They do not conceive of the filling and emptying as a continuous even inflow but as a segmental series of individual contractions. These authors state that complete contractions of the various calices are strong roentgenologic evidence against chronic infection (Fig. 19). They have shown, also, that in patients who have had a recent extirpation of one kidney, the remaining kidney may display increased size of the calices and disturbed peristalsis of its pelvis, because of the extra load thrown upon it.

Fig. 17. Left: Collecting phase of calyx. Right: Emptying phase. Permission to use illustration granted by Dr. Narath (24).

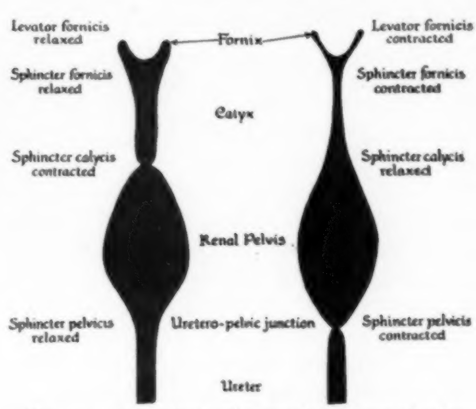

Fig. 18. Collecting and emptying phases of calyx with co-operation of the uretero-pelvic junction. Permission to use illustration given by Dr. Narath (24).

The method used by Jarre and Cumming (16) is the best that I have been able to

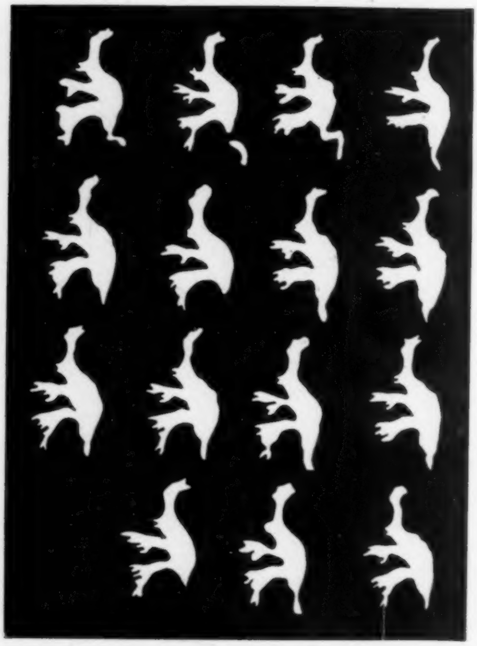

Fig. 19. Tracings of urographic exposures made by the cinex camera (16). This patient is recovering from acute pyelonephritis. There is incomplete caliceal contraction, which is regarded as evidence of residual disease. Permission to use this illustration granted by Dr. Jarre.

find for observing the physiological changes in the renal pelvis. It is impossible with the present facilities to observe them fluoroscopically. In that it has not been practical for us to use the cinex-camera method, we have employed multiple films, multiple exposures on a single film, and films exposed in varying positions which, after a fashion, give considerable information concerning the physiological changes occurring in the renal pelvis (Fig. 20).

Elasticity of the pelves and calices exerts a significant influence on transportation of the urine. A simple method of determining elasticity is to record the size of the calices in roentgenograms made in the supine and inverted positions. In the normal subject, the calices and pelves are larger in the inverted position (Figs. 21A, B, and C). If there is considerable change in size there is no difficulty in stating that normal elasticity is present. If the pelves and calices are rounded and enlarged and do not contract or distend in the suitable posture, it is justifiable to state that the elasticity has been damaged and the process is irreversible.

By the phrase "emptying of the kidney pelvis" we imply that the dye present in the recumbent posture disappears partly or completely in the erect posture (Fig. 21C). Such an observation can be made readily from retrograde pyelographic studies made in the horizontal and erect postures, but I would issue a word of caution against placing too much reliance on residual dye in the kidneys within the thirty-minute period of urography as evidence of disturbed emptying. As a matter of fact, the renal pelvis during that period is never entirely empty. Some of the reasons for the poor reliability of this evidence are as follows:

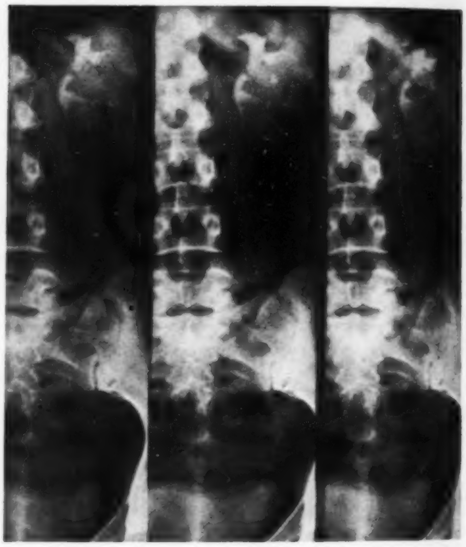

Fig. 20. Serial exposures of the urinary tract on one side. In the roentgenograms, one can demonstrate physiological changes when present, as concerned with the size and shape of the calices and pelvis. The various portions of the ureter can be recorded if it contains dye.

(*a*) There may be a temporary disturbance of the peristalsis of the renal pelvis due to functional and hydrodynamic influences.

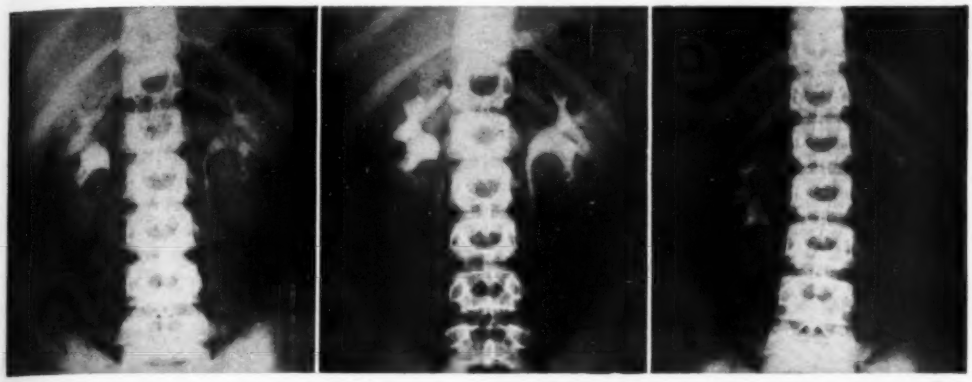

Fig. 21. A. Urographic study illustrating normal elasticity of the calices and pelves. Roentgenogram made in the supine position.
B. Roentgenogram of the same patient made in the inverted position. Compare the size of the pelves and calices in this roentgenogram with A. The structures are quite elastic.
C. This roentgenogram was made in the erect posture. The pelves and calices have largely emptied, illustrating that there is no disturbance in transportation of the urine.

(*b*) If the time between exposures in the two postures is prolonged, additional dye may be excreted and refill the pelves.

(*c*) If the interval is short, there may have been too few peristaltic waves to empty the pelvis.

(*d*) The capacity and elasticity of the renal pelvis are undoubtedly influenced by over-distention of the bladder.

URETERS

The ureters are quite variable in the normal subject. Serial roentgenograms are required to demonstrate the entire length of this organ. The diameter changes markedly due to peristalsis. We have found that films exposed in the supine, erect, prone, oblique, and inverted positions give important information about the ureter as well as the kidney. Roentgenograms made in the prone and inverted positions, will, as a rule, reveal more dye than those made in other positions (Fig. 21B).

Kymograms of the tract, after an intravenous contrast medium, often supply information on peristalsis and tone (Figs. 22A and B, 23A and B). The usual normal is 4 to 8 peristaltic waves a minute. The diameter of the ureteral lumen varies from 0 to 0.6 cm. If no peristalsis is present and the ureter is atonic, the diameter is excessive and, of course, very few or no peristaltic changes are seen. Every portion of the ureter may be studied with such a procedure. The procedure of urokymography has been used and described by Maintz and his co-workers (19). Their observations are based on urokymograms following retrograde pyelography. The urokymogram made under such circumstances shows good contrast, but we feel that the observations are more difficult to evaluate because of the instrumentation.

The position of the ureter depends, in many instances, on the posture during exposure of the films. In the supine position, the ureters extend downward from the kidney pelves along a line several centimeters lateral to the bodies of the lumbar vertebrae. Just below the wing of the sacrum they follow a gentle lateral curve and when they reach the lower pelvis converge inward to enter the bladder (Fig. 14). In other postures, the position of the proximal portion of the ureters, above the wings of the sacrum, depends largely on the location of the kidney. The pelvic portion of the ureters changes very little except when diseased or displaced.

There are several constrictions in the normal ureter, with intervening spindle-like dilatations. These are located from

Fig. 22. A. Urogram in a patient with tuberculosis of the left upper urinary tract and bladder.
B. Same case as A, showing appearance of bladder and lower ureters.

above downward at the following sites: (*a*) just distal to the uretero-kidney pelvic junction; (*b*) where the ureter crosses the iliac vessels; (*c*) just before the ureter enters the bladder; (*d*) at the intramural portion of the bladder. There are many normal variations in the ureter just as in other structures, but the healthy organ can usually be determined very readily by studying the transportation of the urine.

If the dye in the ureter is seen repeatedly in all roentgenograms or if it is not seen in any, an abnormality is present, which may be due to intrinsic ureteral or to kidney, bladder, retroperitoneal, spinal cord, or other lesion (Figs. 24A and B).

It is not the purpose of this presentation to discuss the abnormal appearances of the ureter, but I would like to place full emphasis upon the importance of that organ. That which disturbs transportation of urine below the kidney pelvis will disturb the clearance of the contrast medium and the whole excretory mechanism in the kidney.

THE BLADDER

The bladder is a hollow organ, chiefly muscle. This musculature acts as a unit in exerting pressure from all sides to force the urine toward the urethra. The size and shape of the bladder vary with the quantity of urine it contains. Its shape, moreover, depends on the pressure of outside objects (Fig. 25). In children the bladder seems relatively larger and in women there occur more deformities from outside pressure. Such variations are to be considered in differentiating intrinsic deformities from those due to external pressure.

The appearance time and density of the bladder dye will assist greatly in determining whether or not clearance is satisfactory. Often the dye is to be seen in urograms recorded five minutes after the contrast medium has been injected. Occasionally, in an early urogram, the dye will appear on one side of the bladder before it does on the other, which represents faster transport in the upper tract on that side, due either to normal variance or a lesion on the other side (Fig. 26).

If postero-anterior, right and left postero-anterior and oblique exposures are made in the horizontal posture, and in certain instances in the erect position, most information will be obtained. These

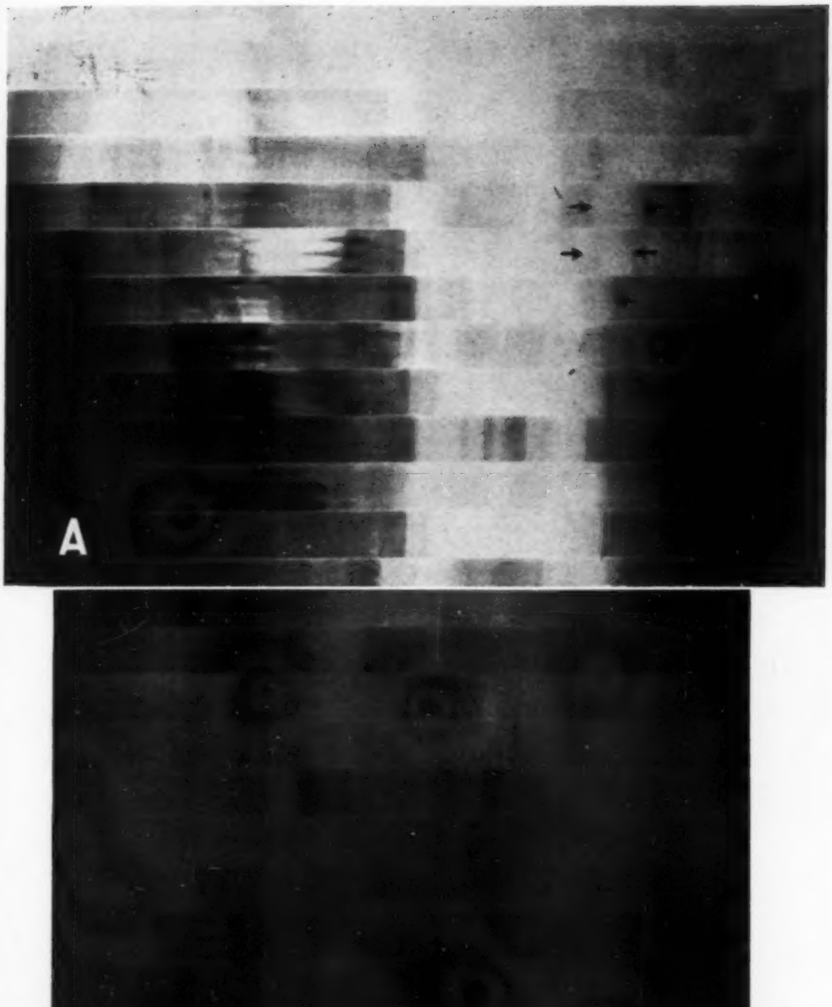

Fig. 23. A. Urokymogram of the upper urinary tract in a patient with tuberculosis of left upper urinary tract. Same case as Fig. 22. Note the "shadow changes" in the pelvis on the right side, produced by peristalsis. There were three waves in thirty seconds (indicated by arrows). The ureteral shadow is not seen on the right.

On the left side, no peristaltic contractions could be demonstrated. The ureter is atonic, as indicated by the dilatation and absence of peristalsis. The shadow of the ureter is indicated by the arrows.

B. Same case as A. The peristaltic contractions in the right ureter are indicated by arrows. They are not seen on the left side. The position of the left ureter is outlined by arrows.

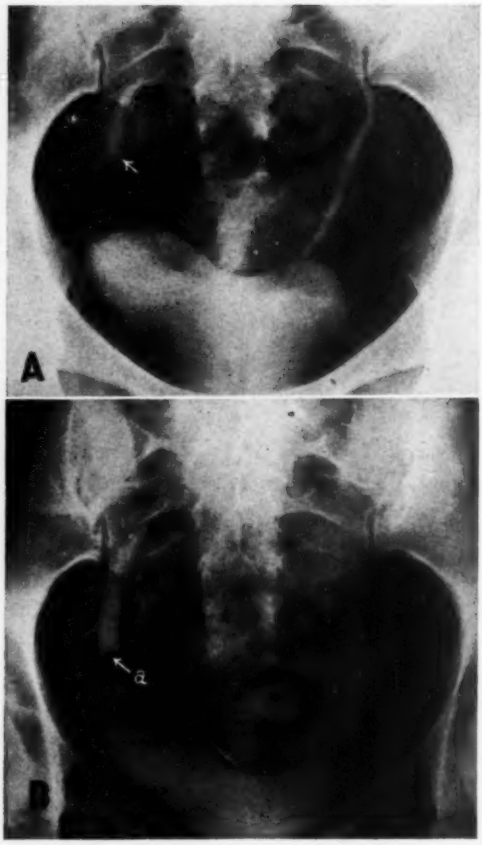

Fig. 24. A. Endothelioma of the right ureter. In this urogram the dye shadow is seen in each ureter.

B. Same case as A. This roentgenogram was exposed shortly after the one reproduced above. The dye in the left ureter has emptied into the bladder. On the right side the deformity produced by the endometrial transplant is seen at *a*.

exposures should be made during the latter part of the urographic examination.

According to Eisendrath and Rolnick (8), as soon as a small amount of urine is present in the bladder a pressure of 6 to 10 cm. of water develops and is maintained in a remarkably constant fashion until a considerable quantity of urine accumulates. The intravesical pressure is influenced by psychic stimuli (sounds and odors), temperature of air, postural changes and activity, all of which may increase or decrease intravesical tension (8). When the tension reaches 18 to 30 cm. of water, there is desire to urinate (8). The mechanism of emptying depends upon whether there exists a normal desire to void and whether circumstances permit it (8). In our study of the roentgen appearances before and after emptying, the observations are limited to those seen with voluntary urination.

Studies after urination will reveal the effectiveness of bladder emptying, perhaps calculi in the lower end of the ureter, or other lesions in the ureters or bladder

Fig. 25. Roentgenogram illustrating the bladder shadow. The deformity is due to outside pressure.

that are otherwise obscured by the bladder dye. Without obstruction, very little dye will be seen after voiding (Figs. 27A and B).

Intrinsic lesions of the bladder, as well as lesions of adjacent and spinal cord structures, may not only produce dysfunction and deformities of the bladder, but

secondarily cause dysfunction of the upper urinary tract.

CONCLUSION

In this presentation, my efforts have been to review briefly (1) some of the phases of anatomy and physiology that should be considered in doing a urographic study; (2) the methods used to record the clearance and transportation of the contrast medium; (3) suggestions concerning the interpretation thereof. Further progress certainly will occur and urokymography provides one method for future investigation.

Fig. 26. Urogram illustrating transportation of the urine. Note that the dye shadow is seen in the bladder on the right side and not on the left. The urine containing the dye in the left ureter has not yet reached the bladder.

Excretory urography is recognized as a definite contribution to urologic radiography. At present, it is an unsurpassed roentgen method of estimating total urinary tract function if our interpretation is based on physiological principles.

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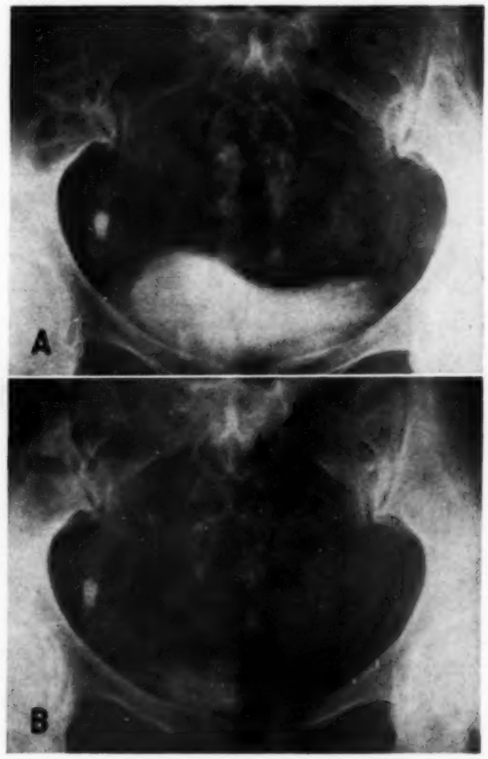

Fig. 27. A. Urogram at twenty-five minutes in a patient who has a stone in the lower end of the right ureter.
B. Roentgenogram of the same patient after voiding. Very little urine remains in the bladder.

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Development of Bone in Relation to the Formation of Neoplasms[1]

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The following paper was prepared for a symposium on bone tumors, and the author makes no claim to originality for the theories which are presented. Chief credit for the emphasis on the relationship between the development of cartilage into bone and the transformation of normal tissue into malignant neoplasm should be given to Geschickter and Copeland, whose text, "Tumors of Bone," is well known.

THE KEY TO A clearer understanding of the origin and growth of bone tumors is to be found in a consideration of the developmental and reparative processes of normal bone. In the embryo, the skeletal system is formed by the differentiation of mesenchymatous cells. The bones of the face and vault of the skull (membrane bones) ossify directly from the mesenchyme. All other bones are preceded in development by hyaline cartilage, which is formed by the activity of mesenchyme cells which secrete about themselves a matrix rich in chondromucin. On the surface of the cartilage is found the fibrous perichondrium, whose inner layer of cells forms new cartilage.

Ossification centers appear in the embryonic cartilage, as a general rule, at three points, one near the middle of the shaft (the diaphyseal center) and one at each end (the epiphyseal centers). The cartilage cells near the ossification centers become arranged in rows, the matrix lying between these rows of cells is absorbed, and finally even the cartilage cells disappear. The cartilage trabeculae undergo ossification to become bone trabeculae, between which the primitive bone marrow is formed. The perichondrium, becoming periosteum, lays down cortical bone by the action of osteoblasts. Channels are formed through the cortex by the work of osteoclasts, and these channels become the haversian systems through which blood vessels pass.

A plate of hyaline cartilage remains between the epiphysis and the shaft and permits increase in length of the bones until the end of the period of growth, when the epiphyseal line closes. The diameter of the long bones increases through the laying down of new bone beneath the periosteum and the gradual resorption of bone lining the medullary cavity. Thus, from before birth until about the twenty-first year, a constant transition is taking place from precartilaginous connective tissue to cartilage, and from cartilage to bone. It is at such points of transition, as we shall see, that the majority of bone tumors, both benign and malignant, arise.

Passing briefly to a consideration of the reparative processes of bone, we find the subject confused by the multiplicity of points of view. These boil down to three main theories of bone repair, as indicated by the accompanying diagram. The periosteal theory, first advanced by Duhamel in 1741, attributes to the cells of the periosteum and of the endosteum the power to form new bone. A somewhat similar theory of the formation of new bone by cellular activity assumes that the active cells (osteoblasts) arise from fibroblasts or from bone cells of the cortex. Opposed to the conception that new bone is formed by cellular action is the so-called biochemical theory that injury to bone results in the deposition of calcium salts in the extracellular framework of connective tissue, with the imprisonment of the connective-tissue cells, which become bone cells. No matter which of these theories is favored, all authorities agree that the

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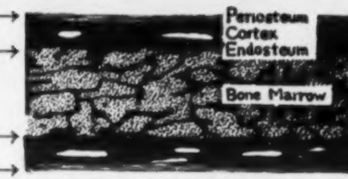
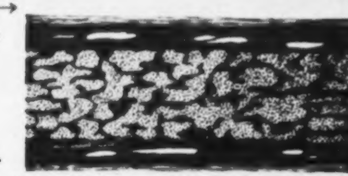
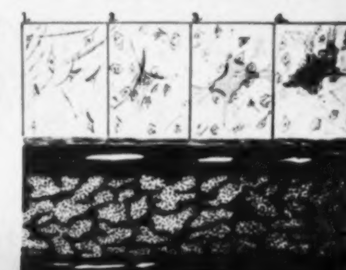
THEORIES OF BONE REPAIR

TITLE	ADVOCATES AND YEAR	OSTEOGENIC ELEMENTS	STRUCTURE OF BONE (DIAGRAMMATIC)
PERIOSTEAL	DUHAMEL 1741. SYME 1835. OLLIER 1867 AXHAUSEN 1898. HAAS 1913. MAYER & WEHNER 1914. PHEMISTER 1914. BERG & THALHIMER 1918. RHODE 1925. BLAISDELL & COWAN 1926. MOCK 1928. HAM 1930.	Periosteum → Endosteum → Endosteum → Periosteum →	
OSTEOBLASTIC 1. BONE CELLS 2. FIBROBLASTS	GOODSIR 1841. MACEWEN 1912. BROWN & BROWN 1913. DAVIS & HUNNICUT 1915. GALLIE & ROBERTSON 1919. KEITH 1927 JAFFE 1929.	Fibroblasts → Bone Cells → Bone Cells → Fibroblasts →	
EXTRA-CELLULAR DEPOSITION OF CALCIUM SALTS	BANCROFT 1922. LERICHE & POLICARD 1928. MURRAY 1930.	PHASES OF OSSIFICATION LERICHE & POLICARD 1. Edema of connective tissue. 2. Multiplication of fibrils. 3. Deposition of pre-osseous substance. 4. Calcification.	

fracture of a bone sets up a series of local changes which pass through the stage of hemorrhage, followed by fibrin deposition and organization of the clot to form an embryonic type of connective tissue in which calcium and phosphorus are laid down in the proportion found in bone. Simultaneously there occurs the death of the bone cells near the ends of the fracture fragments with subsequent gradual replacement of the dead cells with living cells by the process called "creeping substitution."

During the process of repair following fracture, a variable amount of hyaline cartilage is seen. Apparently, a considerable mobility of the fractured ends of the bone favors the development of cartilage. In many sections, no cartilage is seen in the masses of callus. Although one explanation of the formation of tumors in general is an uncontrolled continuation of reparative processes which have been initiated by an injury, it does not seem probable that tumors of bone arise in this manner. The great frequency of fractures and the extreme rarity of known examples of tumors arising at a fracture site are strong evidence against such an explanation of tumor growth. The role of trauma in the production of bone tumors is a question which we shall not undertake to discuss, but shall leave to the industrial accident commissions.

Most primary tumors of bone arise in connection with transitions of growth. A classification of bone tumors based on their association with phases of osteogenesis has been suggested by Geschickter and Copeland in their *Tumors of Bone*, as follows:

Group I. Tumors related to osteogenesis.

A. Tumors derived from precartilaginous connective tissue
 1. Osteochondroma or benign exostosis
 2. Chondroma or benign chondromyxoma
 3. Primary chondromyxosarcoma
 4. Secondary chondromyxosarcoma
 5. Osteoblastic osteogenic sarcoma

B. Tumors related to subsequent cartilaginous growth
 1. Chondroblastic sarcoma
 2. Osteolytic osteogenic sarcoma
 3. Bone cyst and osteitis fibrosa
 4. Benign giant-cell tumor.

Group II. Tumors of non-osseous origin.
 1. Primary lymphoma of bone (endothelial myeloma of Ewing)
 2. Multiple myeloma
 3. Metastatic carcinoma
 4. Fibrosarcoma and neurogenic sarcoma

Strands of embryonic connective tissue near joints, having the power to form cartilage or bone, may give rise to benign osteochondromas or to chondromyxosarcomas. In the small bones of the hands and feet, similar strands of tissue may produce central chondromas. After birth, two types of cartilaginous growth occur. The proliferating cartilage cells on the shaft side of the epiphyseal line may undergo calcification and form an osteogenic sarcoma. The other type of cartilaginous transformation takes place on either side of the epiphyseal line and is characterized by the action of giant cells (or osteoclasts), which cause resorption of the calcified cartilage. This process, when it occurs on the shaft side of the epiphyseal line, may give rise to a bone cyst; when it occurs on the epiphyseal side of the line, to a giant-cell tumor.

In a further elucidation of the thesis that tumor formation is related to the transition of cartilage into bone, it is well to consider the more common tumors individually. The osteochondroma, or exostosis, with its close resemblance to the normal structure of bone and articular cartilage, and with its common occurrence on the shaft side of the epiphyseal line at the point of attachment of tendons, is a good example of the relationship of neoplastic development to normal growth. In such locations an embryonic type of cartilage cell, which is found at the attachment of a tendon, is not restrained by periosteum and may continue to grow until it forms a cauliflower-like mass with a narrow neck, where growth is restricted

by a collar of periosteum, and a proliferating cap of cartilage. In a small percentage of untreated or inadequately treated cases, malignant changes will eventually occur.

The multiple occurrence of exostoses is known as hereditary deforming chondrodysplasia and may be accompanied by abnormal development of the skeleton in general. Because of arrested development, precartilaginous tissue may persist in the shafts as well as the ends of long bones, and tumors may be found in many locations. Certain of these tumors, because of pressure on nerves or interference with joints, must be removed. Here, also, there is the possibility of malignant change.

The pure chondromas (often called "central chondromas") are found in the small bones of the hands and feet, arising from aberrant strands of precartilaginous connective tissue of the type which ordinarily forms the joints of the phalanges. Such tumors occur in the center of the shafts of the bones and grow in an expansile manner. Similar tumors in the sternum, spine, or long bones are apt to become malignant.

Primarily malignant cartilaginous tumors, the chondromyxosarcomas, arise from a primitive type of precartilaginous tissue which, as in the case of osteochondromas, is found at the points of attachment of tendons to bones near articular surfaces. Microscopic sections of these tumors show a mixture of rapidly growing cartilage, bone, and myxomatous tissue. They run a rapid and usually fatal course, in spite of any type of treatment.

A different type of malignant tumor is the periosteal osteogenic sarcoma, which is characterized by the formation of bony spicules, often giving a "sun-ray" appearance. These tumors usually arise on the shaft side of the epiphyseal line from the osteogenic layers of the periosteum, at which point the osteoblasts rapidly form large masses of new bone. In this instance, the normal process by which the diameter of a bone increases has gone wild. Cartilage cells are found only rarely in such tumors. The percentage of cures following amputation is higher than in the preceding group.

Rarely, an osteolytic type of chondrosarcoma arises from the cartilage of the epiphyseal line. These tumors are composed of cartilage cells which are undergoing calcification but do not progress to the formation of bone. Eventually a layer of new bone forms at the periphery of the tumor, and giant cells may be seen. Another form of osteolytic sarcoma arises in the subcortical zone of the metaphysis, forming an expansile tumor which resembles a bone cyst but is distinguished from it by the perforation of the bony shell of cortex. The tumor in this instance results from the metaplasia of fibrous tissue of the endosteum into osteoblasts without the intermediary stage of cartilage. The prognosis in both types of osteolytic tumor is poor.

The relationship of bone cyst and giant-cell tumor has been a matter of extended controversy. The bone cyst usually originates before the age of twenty, and the giant-cell tumor after that age. Bone cysts occur in the shafts of the long bones, while giant-cell tumors are almost invariably associated with an epiphysis. Microscopically, the bone cyst would appear to represent the final stage of a healing process rather than an inflammatory or neoplastic reaction. It seems probable that the process is initiated by the occurrence of hemorrhage, which is followed by absorption of the blood and the formation of a cyst lined with fibrous tissue, which becomes converted into bone. The cyst persists unchanged unless its walls are collapsed by fracture or operative interference, in which cases healing of the condition takes place. Multiple bone cysts associated with hyperparathyroidism are termed osteitis fibrosa cystica or von Recklinghausen's disease. These cysts usually contain numerous giant cells, and have a tendency to progress by the confluence of small cysts or by the formation of new ones.

The giant-cell tumor derives its characteristic cell from the osteoclast, which

plays an important role in the transformation of cartilage into bone because of its power to absorb calcified cartilage. According to Geschickter and Copeland, nests of giant cells occur in the shafts of long bones but their growth is stopped by thick cortical bone, and the arrested incipient giant-cell tumor becomes a bone cyst. In fact, these authors postulate that every bone cyst represents the healing stage of a giant-cell tumor. In the epiphysis, a collection of giant cells is not restrained by the thin cortical bone, and an expansile tumor is formed, which may fill the epiphysis. Epiphyseal trauma may be an initiating factor in the development of a benign giant-cell tumor.

A large group of tumors which are found in bones originate in tissues which are not concerned with bone formation. These have not been included in the above discussion. They include the endothelial myeloma of Ewing, multiple myeloma, and metastatic carcinoma.

CONCLUSIONS

1. All bones, with the exception of parts of the skull, are formed by mesenchyme, which first becomes differentiated into hyaline cartilage in the shape of the future bone.

2. The gradual transition of this cartilage into bone begins in the center and at the ends of the long bones and continues until the attainment of maturity.

3. The majority of bone tumors, both benign and malignant, arise at the site of transition from cartilage to bone, and the neoplastic cell bears a resemblance to the precartilaginous connective tissue, to the cartilage cell, or to the osteoblast and osteoclast which are concerned in the actual formation of bone.

4. In general, it may be said that bone tumors are not the result of a failure of the process of bone repair to become arrested, but arise as a distortion of the normal process whereby cartilage is transformed into bone.

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DISCUSSION

Ralph S. Bromer, M.D. (Bryn Mawr, Penna.): Dr. Haldeman has presented the theory of the development of bone in relation to the formation of neoplasms clearly and concisely. He stated in his conclusion that bone tumors are not the result of the failure of the normal processes of bone repair to become arrested, but that they arise as a distortion of the normal process whereby cartilage is transformed into bone. This omits the question of trauma as a causative agent in the formation of neoplasms. It occurred to me that, in order to make the symposium more complete, some of the arguments for and against trauma as a factor in the causation of bone neoplasms might be briefly reviewed.

It is true that the number of cases of bone tumor arising at the site of previous fracture is extremely small, and it is true, too, that it is most difficult to secure fulfillment of the criteria published by Ewing in 1926 for the establishment of a definite relationship between trauma and neoplasm. These criteria are:

1. Authenticity and sufficient severity of the trauma
2. Previous integrity of the wounded part
3. Identity of the injured area with that giving origin to the tumor
4. A tumor of a type that could conceivably result from trauma
5. A proper time interval between the receipt of the injury and the appearance of the tumor.

Hartman states that, from a statistical point of view, bone sarcoma is referred to trauma in from 10 to 50 per cent of cases, but few cases are recorded which satisfy the criteria necessary to demonstrate a relation between the two.

There are thus reasons against the acceptance of the theory of trauma as a cause of, or the activating agent of, neoplastic formation. Can the fact be disregarded, however, that the histologic picture of osteogenic sarcoma shows not only the cells which are found in the transition of normal bone growth and development, but also cells and a histologic picture which resemble the process of repair of fractures with a lack of growth restraint? As Kolodny states, differentiation of the tumor cells leads to bone production, but at the same time the undifferentiated tumor areas continue to destroy bone, analogous to the physiological repair of bone in fractures. The first stage of healing of a fracture is the resorption of the bony spicules and jagged edges of the fragments. Formation of osteoid tissue with calcification is the next stage, when provisional callus is formed.

Slye has produced experimental evidence that trauma may influence malignant growth where hereditary predisposition is present. On the other hand, Karsner states that pathological irritation of cells or tissues may occur in the form of a single trauma, or as a prolonged or frequently repeated injury, but he believes that, except through the inter-

vention of chronic inflammation, a single trauma does not explain tumor growth. Thus it may be said that, while in general bone tumors do arise at the site of transition from cartilage to bone, and the neoplastic cells bear resemblance to the precartilaginous connective tissue, to the cartilage cell, or to the osteoblast and osteoclast, nevertheless this picture is not constant in all bone tumors found in Group 1, Subdivisions A and B, of Geschickter's classification. The resemblance to the picture of unrestrained bone repair is also found in tumors of this group at times, or in diverse situations that can be found only after a search of numerous pathological sections of the tumor. This may be reaction, reparative in nature, but unrestrained, of the normal bone to the tumor growth *per se* or it may be the result of chronic irritation in the form of repeated trauma, or of a single trauma influenced by inflammation, as stated by Karsner. I would like to ask Dr. Haldeman whether, if we accept the theory advanced by him, we must not still consider predisposition, irritation, and lack of growth restraint as factors in the causation of the distortion of the normal process whereby cartilage is transformed into bone which ultimately results in the occurrence and subsequent growth of bone tumors?

(*For continuation of Discussion, see General Discussion of Symposium on Bone Tumors, page 275.*)

A Correlation of Roentgenogram and Pathological Changes in Ossifying and Chondrifying Primary Osteogenic Neoplasms[1]

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Roentgenology is playing an increasingly important role in the diagnosis and understanding of osteogenic neoplasms. It is most heartening to observe the growing co-operation among roentgenologists, pathologists, and clinicians. The roentgenologist no longer limits himself to a view box and fluoroscope; he now goes to the pathologist to examine the histological sections and gross specimens; not infrequently he meets the pathologist coming to him for study of the roentgenograms, and both wish to hear the clinician's history and physical findings. This trio, working together, has accomplished much which has been of mutual benefit. For the roentgenologist it has meant a better understanding of pathological processes. As he views his roentgenograms he visualizes these underlying processes and their genesis; no longer does he see mere shadows; he sees tissues and entities, living, growing, and unfolding their nature before him. The clinician looks to the roentgenologist for information in the diagnosis of bone tumors, and he has responded well to this responsibility. In fact, it is the opinion of many that the roentgenologist makes his best contribution to the profession in the interpretation of osteogenic neoplasms.

Although the problems in this field are many, there are many rewards; the complexities and perplexities of oncology reward us by their fascination. As Ewing has said: "Oncology is the most complex and fascinating field in pathology."

This discussion will be limited to those osteogenic neoplasms which consistently produce bone or cartilage. As a group, they are the tumors that are best represented on the roentgenogram. The various patterns of chondrification, ossification, and osteolysis characteristic of this group make it possible to portray many of their most important features roentgenographically. The following primary ossifying and chondrifying osteogenic tumors will be described:

- I. Benign
  - A. Osteoma.
    - 1. Spongy.
    - 2. Eburnated.
    - 3. Osteoid.
  - B. Chondroma.
    - 1. Solitary.
    - 2. Multiple.
  - C. Osteochondroma.
    - 1. Solitary.
    - 2. Multiple hereditary.
- II. Malignant.
  - A. Osteogenic sarcoma.
    - 1. Osteoblastic sarcoma.
      - (*a*) Sclerosing.
      - (*b*) Osteolytic.
    - 2. Chondrosarcoma.
      - (*a*) Primary.
      - (*b*) Secondary.

Giant-cell tumors, multiple myelomata, and endothelial myelomata are excluded, since they produce no tumor bone or cartilage. The fact that they are frequently responsible for the formation of bone and cartilage as a defensive or healing response does not admit them to this group. Osteogenic fibromata and fibrosarcomata have been known to produce bone and cartilage, but they do this so rarely that it is impractical to include them.

Each tumor will be discussed individually in the order presented in the outline.

BENIGN TUMORS

Osteoma

The osteoma, most benign of bone tumors, is a true neoplasm forming on the basis of intramembranous ossification, and limited, therefore, to those bones which de-

[1] From the Department of Orthopedic Surgery, service of Dr. Arthur Steindler, State University of Iowa Hospitals, Iowa City. Presented, as part of a Symposium on Bone Tumors, before the Radiological Society of North America at the Twenty-seventh Annual Meeting, San Francisco, Calif., Dec. 1-5, 1941.

velop from membrane, that is, by direct ossification in fibrous tissue. This confines the site of this tumor to the skull and the facial bones, except for parts of the ethmoid, mandible, sphenoid, temporal, and occipital bones. Usually appearing during childhood, it occasionally does not make its presence known until adult life.

Osteomata are not nearly so common as osteochondromata, their growth is slow, and they rarely, if ever, become malignant. A broad base is the rule, and the tumor may project from either table of the skull, usually the outer, or into the frontal, maxillary, or other sinuses. The growth is frequently lobulated, and lobes may break off, become free, and undergo aseptic necrosis. It is helpful to remember that in the roentgenogram an osteoma in a sinus ordinarily produces a greater density than would be produced by pus and the irregular sharp outline of the tumor is usually visible, since it does not fill the entire sinus cavity. When growing from the inner table of the skull, osteomata must be differentiated from meningeal osteophytes and traumatic and inflammatory hyperostoses.

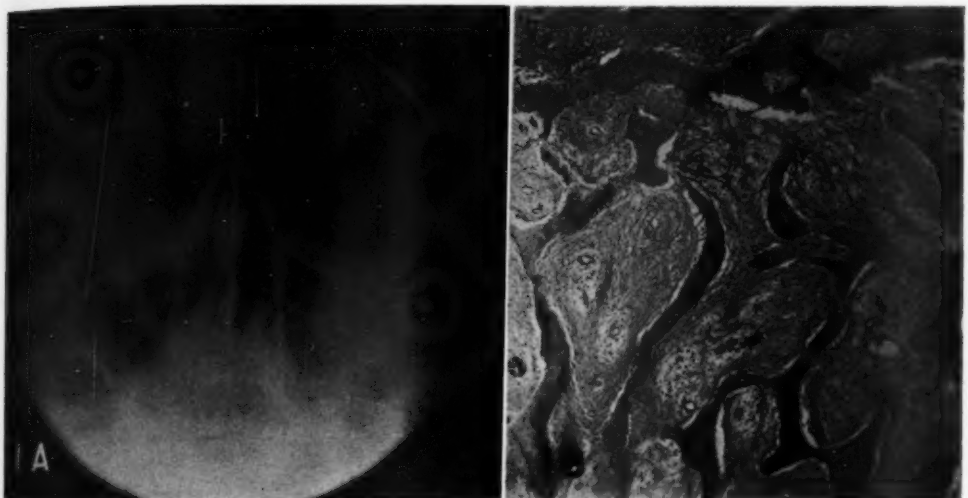
A thin fibrous membrane envelopes the tumor and serves it as a periosteum. Enlargement of the mass occurs by periosteal new bone formation. No circumferential growth can occur in the tumor except beneath this periosteum. Increased density occurs as a result of new bone deposition on the trabecular surfaces or in the walls of the haversian canals. At the termination of growth, a lamellar plate forms at the surface of the tumor, producing a dense cap of bone, which in the roentgenogram is seen as a sharp outlining margin. Such lamellar plates, especially prominent in the spongy type of osteoma, resemble the articular cortex of the long bones.

Of the typical osteomata there are two types; spongy and eburnated. A third type, the osteoid osteoma, has recently been added to the group but not without considerable controversy. It is the writer's opinion that this tumor, and it definitely appears to be a neoplasm, should be included with the osteomata.

Spongy Type (Fig. 1): As the name implies, the spongy type of osteoma is made up of cancellous bone of varying density. Bony trabeculae forming the tumor may be of fine caliber or may be so heavy as to show areas of transformation to compact bone. Marrow elements are usually fibrous but may be fatty, hematogenous, or a mixture of all three types. The histogenesis of this tumor is simply that of fibrous bone. At the outset, osteoid is deposited as small elongated droplets among the collagenous bundles. With gradual enlargement of these osteoid spicules, trabeculae are formed; upon calcification these become bone and, joining one another, set up a system which is cancellous bone. Enlargement of trabeculae occurs through osteoblastic activity, with osteoid being deposited layer upon layer, and then calcifying to form bone, just as in normal bony development. In older tumors fibrous marrow may be replaced by fatty or hematogenous elements.

Eburnated Type: The word eburnated describes the ivory-like density of this type of osteoma. The cancellous or spongy type of osteoma resembles cancellous bone; the eburnated type resembles compact bone. Transformation from cancellous to compact bone is complete when a typical haversian system appears. As would be expected, the central, older parts of the tumor are the most dense and the less mature subperiosteal portion the least dense. A transformation to compact bone can occur only when there has been sufficient time for new bone deposition to transform the cancellous elements into compact elements. In the roentgenogram an eburnated osteoma is readily differentiated from the spongy type by its greater density.

Osteoid Osteoma (Fig. 2): This interesting entity was first described in 1932 by Jaffe. Considerable controversy centers around it and is concerned with whether or not the lesion is a neoplasm or the result of inflammation. There now appears to be sufficient evidence to classify it as a neoplasm and to group it with the osteo-



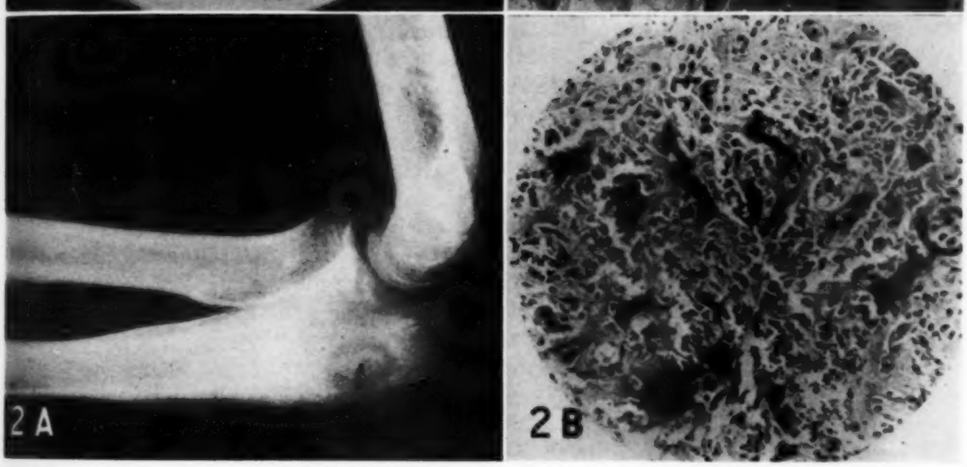


Fig. 1. Spongy or cancellous type of osteoma filling most of the left maxillary sinus. The photomicrograph (B) shows bony trabeculae forming on the basis of fibrous tissue.

Fig. 2. A. Osteoid osteoma. (*a*) Body of tumor. (*b*) Zone of fibrous tissue. (*c*) Reactive periosteal bone. As seen in the photomicrograph (B) only scattered trabeculae are calcified; the others are characteristically in the osteoid stage.

mata. Since Jaffe's original communication, numerous additional reports have appeared in the literature.

Osteoid osteomata may occur at any age, but most cases have been observed in adolescents and young adults. The lesions are monocentric, no cases of multiple tumors having been reported. Though usually occurring in spongy bone, they may occasionally lie directly in cortex. They have been most commonly observed in the phalanges of the hands and feet, the astragalus, os calcis, ilium, and tibia. The lesion is rounded, moderately dense, 5 to 20 mm. in diameter, and is bounded by a narrow zone of little density which sharply outlines the pea-sized tumor body. No gross or microscopic evidence of inflammation has been seen in these tumors; thus, there is no direct evidence on which to place this entity with the inflammations. Some investigators, however, consider it an end-product of inflammation. Most cases are diagnosed roentgenographically

as osteomyelitis, the tumor body being erroneously referred to as a sequestrum. Histologically no necrotic bone, septic or aseptic, is found. In most cases three zones are seen: the central zone, which is the round or oval tumor body, a narrow porous peripheral zone which sharply demarcates the tumor body, and an outer zone of periosteal new bone.

The central area consists of cellular fibrous tissue in which osteoid trabeculae actively form. For some reason not evident from histological studies, most of these trabeculae fail to calcify, although in normal physiological states osteoid trabeculae calcify promptly, or even immediately, to become bone. One of the most consistent characteristics of the osteoid osteoma is this tendency of the trabeculae to remain in the osteoid state, though enough do calcify to present a striking contrast (Fig. 2B). There is both osteoblastic and osteoclastic activity with the osteoblastic phase usually predominating. The histogenesis appears to be that of fibrous bone, with the exception that most of the trabeculae, as already stated, remain in the osteoid stage. In the cancellous structure that forms, trabeculae vary in size but do not undergo transformation to a mature lamellar type of bone or to compact bone.

The narrow zone of fibrous tissue which forms an enveloping membrane around the central portion of the tumor contains no osteoid, bone, or cartilage. The function of this zone is not known.

At the periphery there is usually a periosteal reaction with a small or large amount of periosteal new bone forming directly over the tumor. It is the writer's impression that the erosive action of the tumor finally perforates overlying cortex, the result being subperiosteal hemorrhage, followed by organization and new bone formation. If this is the correct explanation, the periosteal osteophyte represents a reparative or protective response. There is nothing in the periosteal bone to suggest that it is neoplastic, and no inflammatory elements make their appearance in any layer of the tumor or in the adjoining area. No recurrences have been reported following simple enucleation of the central portion of the tumor.

Chondroma

Chondromas (Fig. 3), more frequently solitary than multiple, usually remain small but may grow to large proportions. In contrast to osteochondromata, which occur at the periphery, chondromata usually occur centrally, thus the name enchondroma. At the site of the tumor, the host bone may be greatly expanded and distorted, even perforated, the tumor being identified as a localized or fusiform bulge, sometimes difficult to differentiate from an osteochondroma. While osteochondromata appear predominantly in the long tubular bones, chondromata are more commonly identified with short tubular bones, the more frequent sites being the phalanges of the hands and feet (with the hands predominating), the metacarpals, metatarsals, rib cartilages, and vertebrae; rarely the long bones are involved. The incidence is about equally divided between the sexes; the majority of cases are seen during the first two decades. Many of these tumors, however, are symptomless and may not be diagnosed until adult life, even late adult life. A thin fibrous capsule surrounding the tumor serves as a perichondrium, growth occurring through the activity of its deeper layers.

The irregular grooved tumor surface may be nodular or lobulated, depending upon the depth of the grooves. Palpation of the mass discloses a slight compressibility, a rubbery feeling, though occasionally there is a hard ossified layer on the surface. As a result of trauma, inflammation or malignant change, overlying soft tissues may become securely fixed to the tumor. Cross-section reveals a multilobulated structure with the pale blue, opalescent, wet, glistening appearance of hyaline cartilage. Areas of degeneration are yellow to brown and areas of calcification white to gray. The perichondrium, a thin, film-like enveloping membrane, follows the surface grooves and

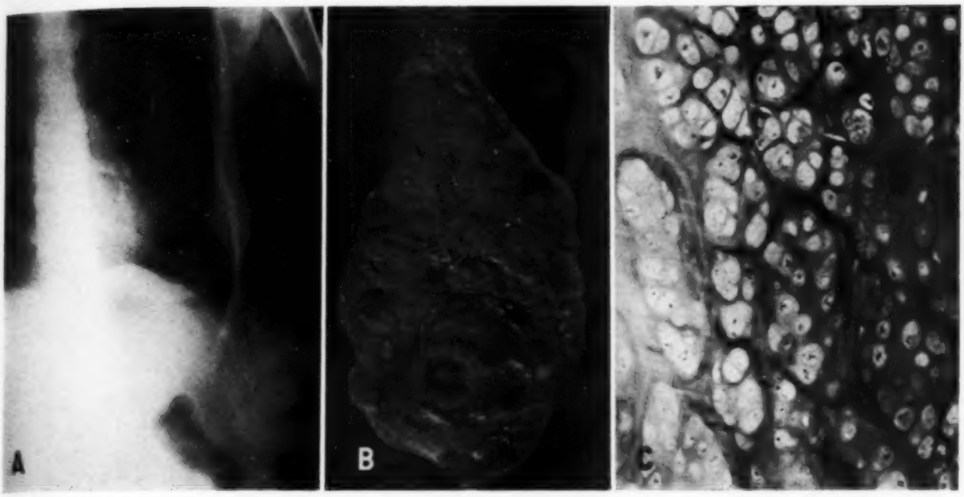


Fig. 3. A. Lateral roentgenogram of a chondroma of the left tenth rib. B. Gross specimen: cross-section showing multilobulation and opalescence. C. Photomicrograph of a typical field in a chondroma.

crevices. Fine strands of white fibrous tissue pass through the tumor in multiple directions, dividing it into numerous lobes. Except for the islands of calcification or ossification, the neoplasm cuts like firm rubber.

The histologic picture is that of hyaline cartilage in various stages of differentiation from embryonic to mature. It is not often possible, on the basis of histology alone, to differentiate a growing chondroma from a chondrosarcoma. For this purpose the roentgenogram is more dependable than the histological sections. Calcification in chondromata may be entirely absent, may be present in scattered areas of microscopic size, or may be so extensive as to present a dense mottling throughout, producing a striking appearance. Expanded cortex overlying the tumor may show microscopic or gross points of perforation, at which points the tumor capsule lies directly against adjacent soft tissues. Areas of degeneration or necrosis occur rather frequently and may undergo lysis to form cysts. Minute or large areas of myxomatous tissue may be present. Formerly thought to represent degeneration, the myxomatous element is now looked upon as representing a definite tissue entity, a stage of differentiation between fibrous tissue and cartilage.

Ossification in chondromata is not the rule. When it occurs, it is by direct metaplasia of cartilage to bone, the most frequent site being at the periphery and not in the center of the tumor.

The histogenesis of this neoplasm is revealed at the periphery within and beneath the perichondrium. That portion of the perichondrium lying adjacent to the tumor possesses the capacity for creating precartilaginous tissue. This primitive tissue differentiates into an embryonic type of cartilage, which in turn matures into hyaline cartilage. Central portions of the tumor are the most mature, peripheral portions the least mature. The width of the zone of immature cartilage at the periphery gives an indication of the rate of growth of the tumor. If this area is wide, growth is rapid; if mature cartilage is present almost to the periphery, growth is slow or is not occurring at all.

Although the etiology of chondromata is unknown, it is the writer's opinion that Cohnheim's cell-rest theory is still the most tenable explanation. Minute islands of primitive cartilage or of precartilaginous tissue from the growing epiphyseal plate

conceivably become pinched off to remain behind and subsequently undergo transformation, by reactivation in growth, into a chondroma. It may be that cartilage-forming cell rests lying in a subcortical position eventually develop into chondromata or enchondromata, whereas similar remnants in a subperiosteal position become osteochondromata. A centrally placed cartilage-forming tumor forms a perichondrium which completely encircles the mass, probably preventing the formation of an enchondral line. A subperiosteal chondroma, on the other hand, would appear to have a better opportunity to attach itself to solid bone, upon which an enchondral line might readily form, thus transforming the tumor into an osteochondroma. The fact that chondromata almost invariably appear centrally, and osteochondromata almost invariably at the periphery, would seem to indicate that mechanical and environmental factors may play an important part in determining the character and form of the tumor. The further fact that under ordinary circumstances both of these tumors cease growing at the end of the growth period may indicate a mutual relationship to enchondral ossification in the epiphyseal plate.

Solitary Chondroma: Solitary chondromata are somewhat more common than the multiple type. The larger chondromata are usually solitary and occur most frequently in the sternum, os calcis, vertebra, and ribs; they are rare in the long bones.

Multiple Chondromata: Multiple chondromata have the same characteristics as the solitary type and may occur in great numbers, producing considerable disability, especially when they appear, as they do predominantly, in the hands and feet. Ollier's dyschondroplasia is sometimes included under multiple chondromata, although actually it should be considered a developmental process stemming from an impairment of enchondral ossification rather than a true neoplasm. It is usually associated with disturbance in longitudinal growth, which is not the rule in enchondromata. Dyschondroplasia frequently disturbs the entire epiphyseal plate, and there is widening of the metaphysis from the subcortical accumulation of extensive masses of calcified and non-calcified cartilage.

Malignant transformation of chondromata appears first as a reactivation of their growth during adult life. Such reactivation should always be considered as malignant until proved otherwise.

Osteochondroma

The osteochondroma (Fig. 4), the most common of benign bone tumors, possesses a cartilaginous cap of variable thickness and projects from the metaphysis or diaphysis of the host bone. Growth occurs in most instances only so long as the epiphyseal plates of the host bone remain open. Any enchondral line may be the site of an osteochondroma; the most frequent sites are, in order, the lower femur, upper tibia, upper femur, upper humerus, lower humerus, lower tibia, pelvis, and vertebrae. The position of an osteochondroma in relation to the epiphysis, metaphysis, or diaphysis depends upon the time during the growth period at which the tumor appeared. Thus, if it developed early in growth, it might be located on the diaphysis at considerable distance from the metaphysis. In any case the tumor remains at its point of origin, and its position changes in relation to the epiphysis merely because the latter, during skeletal growth, grows away from the original location. On the other hand, an osteochondroma occuring *on* an epiphysis always remains in the same position with relation to the epiphysis, regardless of the time in the growth period at which it developed.

For descriptive purposes, osteochondromata may be considered as being made up of three parts: a fibrous capsule or perichondrium, which creates the tumor; the cartilaginous cap in which exists the enchondral line; the osseous element, which is the conspicuous part of the tumor.

The *fibrous capsule or perichondrium* varies from a few micra to a millimeter in thickness and is an intimate part of the

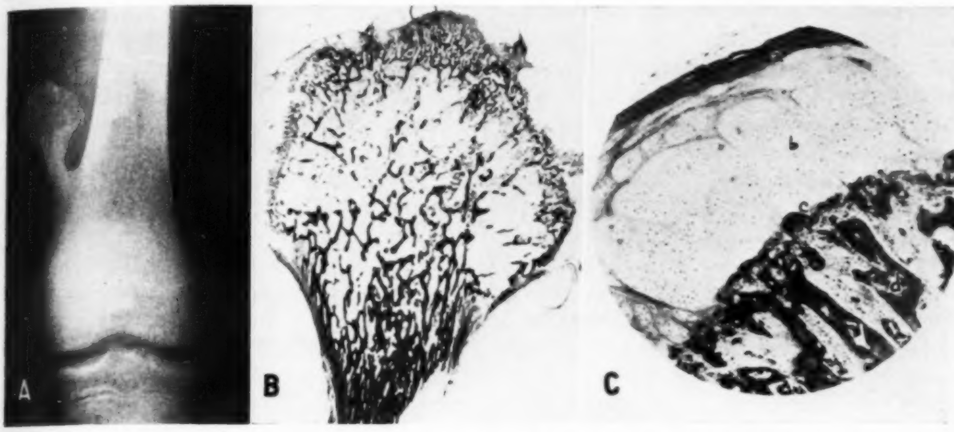


Fig. 4. A. Osteochondroma of left femur. B. Photograph of histologic section of entire osteochondroma. C. Segment of the cartilaginous cap (circle Fig. 4B). (*a*) Zone of "mother tissue" in perichondrium. (*b*) Zone of non-calcified cartilage. (*c*) Zone of calcified cartilage and enchondral line. (*d*) Intratrabecular island of calcified cartilage (indicative of active enchondral ossification).

superficial portion of the cartilaginous cap. It is this perichondrium that creates the tumor. Mother tissue in this structure gives rise to the precartilaginous cells, which in turn mature into chondrocytes. When proliferation in this layer is active, growth of the tumor is active; when proliferation ceases, growth of the tumor ceases. Containing no calcium or bone, the perichondrium is not seen in the roentgenogram, and frequently it is not sufficiently recognized at operation. As might be anticipated, in the excision of osteochondromata, it is essential that this fibrous cap be carefully removed. Histologically, it is not very cellular. Fibrocytes within its superficial layers are elongated and lie in the plane of the tumor surface. Collagenous bundles are visible in the superficial layers but gradually disappear in the deeper layers, in which the mother cells exist and propagate the zone of precartilaginous tissue.

Cartilage, which lies over the tumor like a cap, may be thin or thick, varying from a millimeter to one or more centimeters; its surface is made irregular by furrows of varying depth. This cartilage, hyaline in type, is non-calcified, except for a narrow zone of calcified matrix at the chondro-osseous junction. In superficial layers chondrocytes are of the fetal or embryonic type; gradually growing to maturity, they become adult in the deeper layers of the cap. In spite of the unevenness of the cartilaginous cap at its surface, the enchondral line at the chondro-osseous junction is fairly smooth in contour. In the roentgenogram the cap is poorly defined during the active growing period. After quiescence, at the end of the growth period, bone beneath the cap becomes sharply demarcated as a result of a subchondral lamellar plate. Non-calcified cartilage, thick during the growing period, becomes thin and even invisible, grossly, during the quiescent period.

To know the steps in enchondral ossification is to understand the histogenesis of this tumor. In the growth process the non-calcified hyaline cartilage of the cap becomes calcified at the zone of provisory calcification, and is then replaced by bony trabeculae and marrow elements. There is never direct metaplasia of cartilage to bone at the enchondral line. For descriptive purposes the process may be divided into three steps. First, there is proliferation of chondrocytes in the mother cells of the perichondrium. Second, as the epiphyseal line is approached the matricial substance between the chondrocytes under-

goes calcification to form the zone of calcified cartilage or, as it is sometimes called, the zone of provisory calcification. In normal epiphyseal plates, by the time the chondrocytes have reached this zone, they align themselves in columns—the so-called zone of columns—with the matricial substance in bar-like formation between. In osteochondromata, however, there is rarely a typical column formation. Third, subchondral marrow space capillaries carry in chondroclastic cells to invade the zone of calcified cartilage, releasing adjacent chondrocytes. The exposed calcified matrix points into adjacent marrow spaces and becomes covered with osteoblasts. Soon a bony trabecula forms around the projecting tips of calcified cartilage, and as a new zone of calcified cartilage forms, these projecting bits of calcified matrix are severed, the growth process proceeding, leaving the newly formed trabecula behind. As stated previously, the greater the distance from the enchondral line at which these intratrabecular islands of calcified cartilage can be found, the more rapid is the growth of the tumor. At the end of the growing period, when the epiphyseal cartilage disappears, the zone of mother tissue in the perichondrium ceases to proliferate. Therefore, when all the cartilage of the cap has been replaced by new bone, no further cartilage is available to continue the growth process.

The *osseous portion* of an osteochondroma is normal lamellar bone, being no different in appearance, grossly or histologically, from the compact and cancellous elements of the host bone. At the periphery there is a cortex of compact bone; centrally and beneath the cartilaginous cap the bone is cancellous. The bone nearest the cap is that most newly formed, and the least mature. Away from the cap toward the host bone there is a gradual increase in density and a transformation of cancellous to compact bone. Normal periosteum covers the bony element of the tumor and is continuous with the periosteum of the host bone. Marrow elements in the tumor may be fibrous, fatty, hematogenous, or a mixture of all three. Near the enchondral line of the tumor the marrow is usually fibrous; toward the base it is similar to and continuous with the marrow of the host bone. An osteochondroma may be compared to a normal bone, the diaphysis corresponding to the pedicle of the tumor, the expanded portion of the pedicle adjacent to the cartilaginous cap corresponding to the metaphysis, and the cartilaginous cap being comparable to the epiphyseal plate. It is no wonder that these tumors have been described as peripheral fragments of epiphyseal plate growing independently.

Multiple Hereditary Osteochondromata: Hereditary deforming chondrodysplasia, as this condition is also called, is a well established entity characterized by multiple osteochondromata developing during the period of skeletal growth on the metaphyses of many or most of the long bones, as well as on any of the other bones that form on the basis of enchondral ossification. There is an important hereditary factor, the disease having been traced through as many as five generations; it is transmitted by both sexes. Nearly always observed in the first decade, it leads to skeletal deformity and localized disturbance of growth. Wide variation in the size and shape of the different osteochondromata is the rule, notwithstanding the fact that they usually occur simultaneously in many metaphyses. As length growth of involved bones occurs, the osteochondromata are left behind, their eventual position on the metaphysis or diaphysis depending in large degree on the rate of growth in the adjacent epiphyseal plate. For instance, at the end of skeletal growth an osteochondroma from the lower femur or upper tibia will be farther from the knee than an osteochondroma from the lower tibia will be from the ankle, provided they originate simultaneously, since the total growth contributed by the epiphyseal plates of the lower femur and upper tibia is nearly twice that from the plate of the lower tibia.

Secondary chondrosarcoma occasionally

develops within an osteochondroma, the incidence being given at from 1 to 7 per cent. Malignant transformation occurs principally in the fibrous zone or perichondrium of the cap. The most important single sign of impending malignant transformation is a reactivation of growth in the tumor after about the age of twenty; such reactivation should be looked upon with suspicion and be considered as malignant until proved otherwise.

MALIGNANT TUMORS

Osteogenic Sarcoma

In an osteogenic sarcoma, as in a normal skeleton, fibroblasts, chondroblasts, and osteoblasts are the principal cells with which we are concerned. These cells appear in various combinations and degrees of immaturity. A completely differentiated state does not occur, there being invariably some degree of anaplasia and pleomorphism; in general, the more anaplastic the component tumor cells, the more malignant the tumor. In every instance, one of the three types of cells mentioned dominates the picture and determines the type of osteogenic sarcoma. Each type presents certain characteristics which usually set it apart, at least grossly and histologically, from the other members of the group.

Histologic studies of osteogenic sarcomata have done much to support the theory of specificity of the osteoblast and chondroblast. There are investigators who credit these cells in their primitive state with no predestined future as creators of bone or cartilage, believing that environment is the factor which determines their eventual function. Against this theory is the fact that in osteogenic sarcomata the metastases create a tissue characteristic of the primary tumor. When a cluster of malignant osteoblasts enters the blood stream and later lodges in the pulmonary alveoli, neoplastic bone is produced similar to that in the original tumor, though certainly the lung tissue could not be considered as an environment that would encourage a fibroblast or mesoblast to become an osteoblast. In the same way, chondrosarcomata metastasize to form cartilage, and fibrosarcomata to form fibroblastic tissue. It is not the writer's opinion that the degree of differentiation of the mesoblast dictates whether the osteogenic sarcoma will be fibroblastic, chondroblastic, or osteoblastic. There is evidence that each type of osteogenic sarcoma is a separate entity, and from its beginning is predestined to be the specific type of tumor it later becomes. All degrees of differentiation are seen in all types, and one type does not, in later stages or in higher degrees of differentiation, become another type. Grouping the various types of osteogenic sarcomata together has added to the confusion rather than diminished it. Overzealous efforts to simplify this complex subject merely cloud the picture. Further investigation will probably clarify the subject by uncovering more of its complexity.

From the roentgenological standpoint, it is generally not possible to make anything other than a group diagnosis of osteogenic sarcoma, but after the pathology of a given tumor has been studied an attempt at further classification should be made. Examination of the entire specimen will permit proper classification in nearly every instance, whereas a biopsy section may not be sufficient. In advanced cases, the roentgenogram frequently presents adequate evidence for an accurate prediction of the dominant cell. There are no pathognomonic roentgenographic signs of primary malignant tumors of bone. As will be pointed out later, most osteogenic sarcomata present, in some degree, all three types of cells, fibroblasts, chondroblasts and osteoblasts, plus the interstitial substances associated with these cells; collagen with the fibroblast, non-calcified and calcified cartilage with the chondroblast, and osteoid and bone with the osteoblast.

Only recently has the periosteal and endosteal fibrosarcoma been found to form tumor bone. On the basis of our present experience, ossifying fibroblastic osteogenic sarcoma is so rare that it has not been con-

Fig. 5A. Roentgenograms of a sclerosing osteoblastic sarcoma. A Codman reactive triangle has formed at the proximal end of the tumor, both laterally and medially.

sidered practical to include it in this discussion. Chondrosarcomata, both primary and secondary, have had difficulty in attaining their deserved recognition. These are clear-cut entities, and when the whole tumor is examined there is rarely any question as to the preponderance of cartilage and myxomatous tissue. Sites of ossification may be present, but they are reactive, or represent localized transformation of cartilage to bone and not the fundamental tumor tissue. Chondrosarcomata are not rare in relation to other types of osteogenic sarcomata. They are at least as common as osteoblastic sarcomata. Osteoblastic or ossifying sarcoma is the most frequently recognized type, especially the sclerosing form which, in advanced stages, is so conspicuous in the roentgenogram. Osteolytic osteoblastic sarcoma is as destructive as the sclerosing form is proliferative. If much delay occurs in the diagnosis of the pure osteolytic form, the diagnosis is soon settled at the autopsy table or by a chest film showing multiple pulmonary metastases. This is the most deadly and most rapidly growing of the osteogenic sarcomata.

The mere taking of anteroposterior and lateral roentgenograms of the suspected site is not enough. Films should be taken at various angles, with under-exposures to show soft tissues and over-exposures to demonstrate alterations in densely calcified or ossified areas. Nor is it enough to examine merely the site of a suspected lesion; the opposite side of the body should be studied and in many instances roentgenograms of the entire skeleton must be made. The clinician should advise the roentgenologist of his clinical findings and point out the exact site of pain, tenderness, and swelling. Persisting unexplained pain in a metaphyseal region should spur the roentgenologist to intensive and repeated effort to demonstrate the lesion. When the tumor is palpable and easily visualized, it is already advanced.

Roentgenograms should be analyzed systematically; a good method is to analyze each individual structure in the plate before considering the picture in its entirety. The following methods of analysis will be followed in discussing osteogenic sarcoma: (1) Site of origin: (*a*) central, cortical, periosteal, and paraosteal; (*b*) epiphyseal, metaphyseal, and diaphyseal. (2) Destruction: pattern and extent. (3) Proliferation: pattern and extent. (4) Extracortical: state of periosteum, and adjacent soft tissues. (5) Cortical: state of cortex. (6) Subcortical: state of medullary canal, cancellous bone, and epiphyseal plate.

Sclerosing Osteoblastic Sarcoma (Fig. 5, A, B, C): The majority of sclerosing osteoblastic sarcomata begin in the cambium layer of the periosteum. As the tumor cells multiply, the periosteum is elevated and capillaries in the tumor tissue tend to assume a perpendicular arrangement in relation to the cortex of the host bone. Tumor bone trabeculae may form in this early stage, and these also tend to assume an alignment perpendicular to the cortex, giving the appearance in the roentgenogram of the nap on a rug. Later, as the periosteum becomes more elevated and the tumor dome-shaped, the classical sun-ray spicules make their appearance. Non-

Fig. 5B and C. B (above). Histologic section of the distal half of the specimen (Fig. 5A). Except for the distal portion of the medial condyle, all marrow spaces shown are filled with tumor bone. There are several perforations in the epiphyseal plate. C (below). Photomicrograph from the section shown in B. Tumor bone is actively forming in marrow spaces and at several points has formed on the surfaces of the three normal trabeculae. (*a*) Normal bone. (*b*) Tumor bone.

Fig. 6. Histologic section made from a lower femur. Arrow points to a Codman reactive triangle proximal to an osteoblastic sarcoma. The triangle, composed of non-neoplastic fibrous bone, has its apex where periosteum meets cortex, and a base formed by the extracortical tumor mass.

tumor bone, except at the periphery, is gradually lost. Spicules responsible for the sun-ray appearance are composed of tumor bone, but are not pathognomonic of bone sarcoma. Although these spicules may greatly enlarge and persist, they are commonly lost as the tumor enlarges. This loss occurs because of several factors, the most evident being perforation of the periosteum with the release of tumor cells into adjacent soft tissues, degenerative changes, areas of necrosis, hemorrhage, and the destructive action of the tumor cells themselves.

At the outset, radiating spicules are composed of osteoid or poorly calcified bone. This fact, plus their very fine, almost hair-like caliber, renders them capable of casting only the faintest shadow in the roentgenogram. For their demonstration soft-tissue exposures are necessary, and should be taken in several planes to insure the patch of spicules being brought into profile on at least one of the plates. A "sun-ray" structure may also appear in Ewing's tumor, hemangioma of bone, various bone infections, and after a subperiosteal hematoma. To state dogmatically that a bone sarcoma exists merely because of the presence of "sun rays," is to invite an erroneous diagnosis. There was a time when a diagnosis of a bone sarcoma was reluctantly made unless the roentgenogram disclosed radiating spicules. I am certain that there are none who still cling to that misconception.

In roentgenograms taken during the growing years, a localized thickening or elevation of the periosteum, particularly over the metaphyses, should be viewed with suspicion and restudied at close intervals. If the area grows in length or in thickness, it should be considered as a primary malignant bone tumor until proved otherwise. It is unusual to see and diagnose osteogenic sarcoma at this early stage, the pain being insufficient in most cases to bring the patient to a physician. In the early stages it is not necessary —and frequently not possible—to classify the tumor as sclerosing or osteolytic. It is enough to classify it as osteoblastic sarcoma histologically and as osteogenic sarcoma roentgenologically.

As the extracortical portion of the tumor growing beneath the periosteum passes from the early stages to the more advanced stages, the periosteum is increasingly elevated. Reactive periosteal bone forms, but only rarely over the mound-like mass of the tumor. At the diaphyseal pole of the tumor however, where the periosteum reunites with the bone, a triangular osteophyte is produced, the apex of which lies where periosteum meets cortex, the tumor forming the base, and the elevated periosteum the hypotenuse (Fig. 6). These marginal periosteal osteophytes are called Codman reactive triangles, having been mentioned by Codman as one of the earlier signs of bone sarcoma. The presence of

this sign, however, by no means gives assurance of an early stage of bone sarcoma. A reactive triangle may not appear until the subperiosteal mass is fairly large and may persist into the far-advanced or terminal stages of the tumor. Although in no way pathognomonic, it is undoubtedly one of the most significant and important signs of primary malignant growth in bone.

At the outset, following elevation of the periosteum by the growing tumor, the space between cortex and periosteum at the site of the future reactive triangle fills with granulation tissue, which is readily transformed to cellular fibrous tissue. Among the collagenous bundles of this fibrous tissue, spicules of osseomucin are deposited, which join to become osteoid trabeculae, most of which are perpendicular to the cortex. Cambium layer osteoblasts align themselves on the trabecular surfaces, following which the trabeculae enlarge, calcify, and become integrated into a cancellous bony network. These reactive triangles appear to offer a barrier to further extension of the tumor beneath the periosteum. At the epiphyseal pole of the tumor periosteal elevation is limited in children by the fusion of the periosteum to the epiphyseal plate, and in adults by the fusion of the periosteum to the margin of the articular cartilage.

Perforation of periosteum may occur early or late, but in the sclerosing type of osteoblastic sarcoma it is expected to occur late. When perforation occurs, there is not a large erosion with wholesale destruction of periosteum, but rather there are columns or spearheads of tumor cells which advance beyond the main line of the tumor by eroding their way through periosteal openings of microscopic proportions. Several such columns may perforate the periosteum simultaneously or nearly so, after which their extraperiosteal position is consolidated by great numbers of tumor cells pouring through the perforations. In this way, a large mass of invading cells may accumulate extraperiosteally, with the major part of the periosteum long remaining intact and sandwiched between subperiosteal and extraperiosteal components of the tumor. Tumor cells appear to exert their most destructive action against barriers to their advancement. Once the barrier has been penetrated sufficiently to release advancing cells, the remainder of the barrier may long remain unaltered.

After perforation of the periosteum, a variable zone of fibrous tissue usually forms as a defensive wall ahead of the advancing tumor margin. Such fibrosis varies widely in its ability to halt, temporarily, the aggressive tumor cells. In sclerosing osteoblastic sarcoma, the wall frequently gives the appearance of a fairly substantial barrier. Since reactive bone and cartilage rarely form in this peripheral zone of fibrosis there is little to identify it roentgenographically.

A sharply outlined mass in the roentgenogram is probably not a malignant bone tumor; after radiation therapy, however, a sclerosing osteoblastic sarcoma may temporarily present a clear-cut outline. This is due to increased tumor cell differentiation in the radiosensitive anaplastic margin of the mass and the proliferation of tumor bone that promptly follows the therapy. Radiation therapy temporarily increases the differentiation of tumor osteoblasts throughout the tumor, but since anaplasia is greatest at the margin, new tumor bone is most evident at that site (Fig. 7).

Tumor bone varies tremendously in appearance and density, depending principally on the degree of differentiation of malignant osteoblasts. In the sclerosing type of osteoblastic sarcoma there is sufficient osteoblastic differentiation for the formation of a substantial amount of neoplastic bone. With maximal malignant osteoblastic differentiation, a large amount of bone of ivory-like density forms to give the tumor an unmistakable character. Tumor bone may present a pseudo-lamellar structure with a complex pattern of irregular blue cement lines; no true lamellar bone forms, however, from tumor osteoblasts, nor are there any haversian systems. Density of tumor bone may reach a point

where the trabecular pattern is lost, the bone becoming a solid mass or sheet perforated by multiple canals. There is no uniformity of differentiation of the osteoblasts throughout the tumor, and in consequence no uniformity of bone density, which is one of the factors responsible for the wide variation in roentgenograms of these tumors. At any time in the life of the tumor the degree of differentiation may change, locally or diffusely, toward a more anaplastic state and a greater degree of malignancy. Such changes may involve any part of the tumor, but are most likely to occur at the periphery. Still another factor that alters the roentgenogram is the development of localized areas of necrosis, so consistently seen in osteogenic sarcomata. Aggressiveness of the tumor frequently destroys its own blood supply, leaving small or large areas to undergo necrosis, and it is not unusual to see large sequestra. Necrotic areas may undergo lysis and become transformed into cysts filled with a dark brown fluid.

An element of tumor cartilage appears in most sclerosing osteoblastic sarcomata, being most evident in the extracortical portion of the tumor. Considerable confusion has arisen from the presence of cartilage, especially when biopsies have been taken from a field in which cartilage predominated. When the entire tumor is studied, the cartilage element can be seen in its proper proportion, as only a minor part of the neoplasm. It appears as islands, most of which are undergoing some type of ossification. Surrounding the cartilaginous island there may be a rim of tumor bone formed by direct metaplasia, with chondromucin undergoing transformation to osteomucin and chondroblasts being transformed to osteoblasts. A disorderly primitive type of enchondral ossification may also be seen, as a result of which islands of cartilage are replaced by tumor bone. No clear-cut column formation of chondrocytes is seen, but a zone of calcified cartilage is usually present and tumor osteoblasts can be seen applying osteoid to the matrical substance of the calcified cartilage. An occasional intratrabecular island of calcified cartilage may be found to confirm the existence of enchondral ossification. Except for the degree of anaplasia, the picture is similar to that seen in callus formation following a fracture; in callus in children, fields may be seen that cannot be differentiated histologically from osteoblastic sarcoma. In the roentgenogram, multiple small dense islands in the extracortical tumor mass may represent islands of calcified cartilage; these are more common at the periphery of the mass than adjacent to the cortex.

Site of Origin: As pointed out above, the majority of osteogenic sarcomata appear to arise in the cambium layer of metaphyseal periosteum. From this point of origin the tumor grows in all directions, elevating the periosteum and permeating the cortex to enter the medullary canal. There is no doubt that some of these tumors originate centrally, perhaps in the cambium layer cells of the endosteum. After a tumor is well advanced, involving all parts of the bone, it is usually impossible to identify the site of origin. When the origin is inside the metaphysis, the tumor may spread extensively through the cancellous bone and into the medullary canal of the diaphysis before the cortex is penetrated and a subperiosteal mass is formed. In such cases the subperiosteal mass is small in proportion to subcortical involvement. Conversely, when the origin has been subperiosteal, the extracortical mass is usually large in comparison to the subcortical extension of the tumor. Pathologic examination generally reveals more extensive destruction and more widespread ramification of the tumor than were portrayed by the roentgenogram. Osteoblastic sarcoma of epiphyseal origin is occasionally seen in adults but is rare in children. Diaphyseal origin is rare at any age. Extra-osseous osteogenic sarcoma will not be discussed in this paper; it is extremely rare.

State of Cortex: If the tumor begins in the cambium layer of the periosteum, there is relatively early involvement of the cortex, not in the form of wide erosion by the

tumor but as permeation by tumor cells. In the roentgenogram there may be a roughening of the cortex which, together with localized demineralization of a relatively small area of cortex, is an important early sign. Localized demineralization is the response to two factors: (1) hyperemia, increased vascularization being characteristic of all osteogenic sarcomata; (2) the actual destructive action of the tumor cells as they permeate the cortex. There is a gradual transformation locally from compact bone to cancellous bone; that is, the haversian canals become larger and larger, eventually becoming marrow spaces. In the case of slowly growing osteoblastic sarcomata there may be a gradual replacement of cortical bone by tumor bone, and this may result in increased total mineralization rather than demineralization. Localized osteosclerosis is an important early roentgenographic sign.

As the tumor enlarges and as local cortical involvement becomes more extensive, there may be a replacement of nearly all normal cortical elements by tumor bone; in fact, this process may proceed to the point where tumor bone maintains continuity of the host bone. In such instances only occasional normal trabeculae remain, and these are scattered through the tumor bone as isolated islands. Cortical expansion in osteoblastic sarcoma rarely occurs. Pathological fractures in the sclerosing type are the exception.

Subcortical Involvement (Cancellous Bone of Metaphysis, Epiphyseal Plate, Epiphysis, and Medullary Canal of Diaphysis): Malignant osteoblasts enter the marrow spaces of metaphyseal cancellous bone after penetrating the overlying cortex. In early stages, tumor bone may fill the marrow spaces, replacing normal marrow elements. Instead of destroying the normal bone trabeculae of the metaphyseal cancellous bone, tumor bone may apply itself to the surfaces of the trabeculae, and is easily identified by its bizarre malignant appearance, its association with malignant osteoblasts, and its dark purple staining with hematoxylin and eosin. As the tumor

Fig. 7. Roentgenogram of an osteoblastic sarcoma of the fibula. The sharp outline of the tumor appeared following roentgen therapy, and is due to a temporary increase in differentiation of tumor osteoblasts, enabling them to form more tumor bone, particularly in the anaplastic zone at the periphery.

extends, metaphyseal sclerosis may increase or decrease. If the tumor osteoblasts remain differentiated, tumor bone will form and continued sclerosis of the metaphysis will result. On the other hand, if the tumor cells become more anaplastic they become more destructive, and sclerotic areas may then be replaced by areas of pure destruction in which very little normal bone or tumor bone exists. Inside the metaphysis or medullary canal a defensive wall of fibrous tissue seldom forms, normal marrow elements lying adjacent to the advancing margin of the tumor. Extension into the medullary canal of the diaphysis does not usually occur until there has been extensive replacement of the metaphysis by tumor tissue. As a rule, subcortical

tumor bone is more dense than extracortical tumor bone. There are exceptions to this, however. In certain cases of the more sclerotic type, subcortical involvement may never be demonstrable roentgenographically, the large, dense, extracortical mass forming the entire tumor.

The epiphyseal plate long remains a successful barrier to invasion of the epiphysis, the zone of calcified cartilage presenting the greatest resistance to the tumor cells; but as the tumor involves more and more of the metaphysis and comes to lie adjacent to more and more of the epiphyseal plate, the latter is eventually perforated. Such a perforation, microscopic in size at the outset, soon enlarges. Multiple openings in the epiphyseal plate occur as the tumor advances, and in far-advanced stages only fragments of the plate may remain. A filling up of the epiphysis by neoplastic tissue occurs slowly, usually from an eccentric origin. Another barrier is encountered when the tumor reaches the articular cartilage; it is unusual, however, for this type of tumor to advance so far. Generally, before this stage is attained, metastases and death overtake the patient, or a surgeon overtakes the tumor.

Osteolytic Osteoblastic Sarcoma (Fig. 8): There exists no sharp line dividing the sclerosing and the osteolytic forms of osteoblastic sarcoma. While the extremes of each type of tumor show great variations, it is common to find the sclerosing type predominant in one part of a tumor and the osteolytic type in other parts. There are, however, as has already been stated, almost pure forms of the sclerosing type in which great masses of eburnated tumor bone appear as the conspicuous aspect. Conversely, there are osteolytic forms in which practically no tumor bone exists, osteolysis being the outstanding feature.

Considerable confusion has centered around the osteolytic type of osteoblastic sarcoma. Some investigators believe that this tumor represents a separate entity and is not related to the sclerosing form of osteoblastic sarcoma; it has been classified as a malignant bone aneurysm, related to blood vessels rather than to osteoblasts. Due to its destructive character and rapid growth, it is rarely seen in its early stages. When it is first discovered, there is usually a subcortical area of destruction, and this has led to the belief that the origin is more frequently central than subperiosteal. This, however, cannot be stated with certainty, since in almost every case there is an extracortical mass beneath and outside the periosteum. The soft, friable subperiosteal mass grows rapidly and perforates the periosteum to invade adjacent soft tissues much earlier than the slowly growing, less malignant sclerosing form. A Codman reactive triangle may form and may be more conspicuous than in the sclerosing form, there being little tumor bone to impair the sharp outline of the triangle. With greater degrees of anaplasia there are associated an increased blood supply and greater fragility of the tumor. Pulsation of the extracortical mass, from the presence of numerous large vessels and blood sinuses, is not unusual and is the characteristic which led early observers to describe this tumor as a malignant bone aneurysm. On cross-section, many large blood sinuses are seen, so numerous that they may form a larger part of the tumor area than the tumor tissue itself. Histologically, such sinuses are lined by tumor cells, which fact no doubt accounts for the early appearance of pulmonary metastases. This, the most malignant of the osteogenic sarcomata, may have a clinical existence of only a few months before death. There is reason to doubt that few if any patients with this type of osteoblastic sarcoma in its most anaplastic form have recovered. In the majority of cases, metastases have probably occurred by the time diagnosis is made.

Aggressiveness of the cells frequently destroys their own blood supply; as a result, thrombosis occurs and areas of tumor tissue undergo lysis to form cysts. Osteoid and bony trabeculae may be the least conspicuous part of the tumor, and in the most anaplastic forms there may be no true bone anywhere. In all instances, however, there are at least a few fields of osteoid

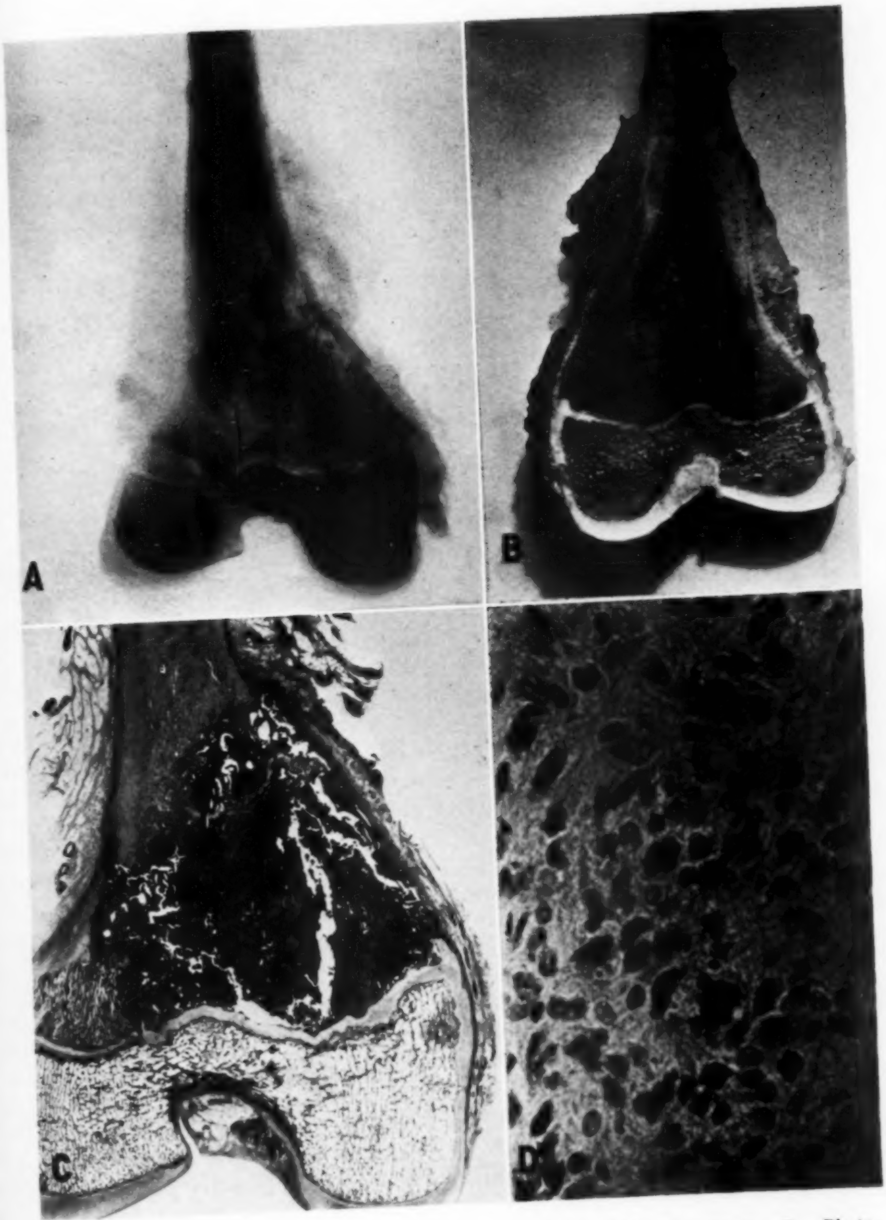


Fig. 8. A. Roentgenogram of specimen of an osteolytic osteoblastic sarcoma. B. Photograph of frontal section of specimen. Much of the friable extracortical mass was lost. C. Histologic section of the entire specimen. The epiphyseal plate is intact. Innumerable large and small blood vessels and sinuses occupy much of the metaphysis. D. Photomicrograph from a section of the extracortical mass. Anaplasia and pleomorphism are pronounced.

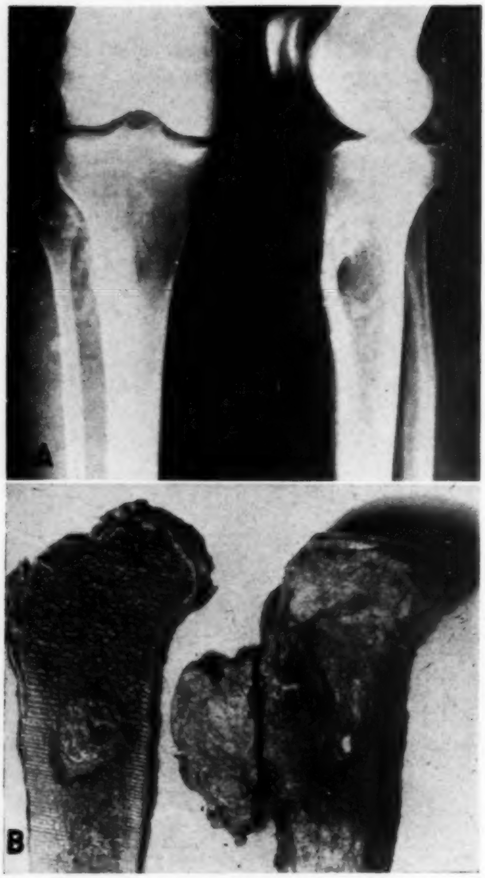


Fig. 9A and B. A. Roentgenograms of a primary chondrosarcoma of the upper tibia. A large cortical perforation exists between subcortical and extracortical parts of tumor. B. Photograph of specimen.

trabeculae. Radiation therapy temporarily diminishes the degree of anaplasia, and the malignant osteoblasts, becoming better differentiated, may give rise to well formed tumor bone. In most instances, there is a rapid reversion to the former anaplastic state with the result that tumor bone formed following roentgen therapy is destroyed. Temporary transformation from the osteolytic to the sclerosing type following roentgen therapy is further evidence of the close relationship between the osteolytic and sclerosing forms of osteoblastic sarcoma.

Site of Origin: The site of origin is probably the same as for the sclerosing form. By the time most osteolytic osteoblastic sarcomata are diagnosed, there is destruction centrally and in the overlying cortex, and an extracortical mass has formed, thus making it extremely difficult to identify the exact site of origin.

Cortex: At the outset the picture is that of localized demineralization, later giving way to advanced and frequently complete destruction of the cortex over or beneath the tumor. Pathological fractures are common and may represent the first symptom prompting the patient to consult a physician.

Subcortical Involvement (Cancellous Bone of Metaphysis, Medullary Canal of Diaphysis, Epiphyseal Plate, and Epiphysis): The central area of metaphyseal destruction, so consistently observed in this tumor, bears a superficial resemblance to a bone cyst, but the margins of a cyst are sharply defined, the cortex is expanded and intact, and growth is slow, whereas in osteolytic osteoblastic sarcoma the margins are poorly defined, the cortex is perforated and not expanded, and growth is rapid.

Contrary to what might be expected, perforation of the epiphyseal plate may not occur in the osteolytic form. That portion of the metaphysis adjacent to the plate is prone to become involved in multiple blood sinuses with little tumor tissue remaining to exert its aggressive action. There are, of course, cases in which both the epiphyseal plate and epiphysis are largely destroyed. Perforation of the joint is not unusual; this does not ordinarily occur through the articular cartilage but rather by an extension of the extracortical mass through the joint capsule. As in other osteogenic sarcomata, the full extent of the tumor is not portrayed on the roentgenogram.

Roentgenographically the osteolytic type of sarcoma cannot consistently be differentiated from Ewing's tumor or even from carcinomatous metastases of osteolytic type. There are no pathognomonic signs, but the rapid rate of growth, the age incidence, the solitary site, and the metaphy-

Fig. 9C. Photomicrograph showing the histogenesis of a chondrosarcoma: from (*a*) fibroblastic tissue to (*b*) myxomatous tissue to (*c*) cartilage.

seal location are all helpful in differential diagnosis.

Chondrosarcoma

Primary Chondrosarcoma (Fig. 9, A, B, C): The incidence of primary chondrosarcoma is approximately that of osteoblastic sarcoma. Origin and distribution are about the same except for the more common occurrence of chondrosarcoma centrally in the upper femur and upper humerus. Although the exact genesis is not known, the tumor is believed by some to arise from precartilaginous cell rests near the surface of the cortex within tendinous attachments. This precartilaginous tissue, which normally functions in maintaining tendon length during skeletal growth, undergoes malignant transformation to become a chondrosarcoma. The incidence, highest during the second decade, in later decades exceeds that of osteoblastic sarcoma. This is especially true at such sites as the upper femur and upper humerus.

Extracortical Involvement: In early stages the roentgen picture of primary chondrosarcoma is similar to that of osteoblastic sarcoma and the two cannot be

differentiated. There is early localized elevation of the periosteum and there may be a delicate "sun-ray" pattern. The radiating spicules, however, are usually of finer caliber and cast a fainter shadow than in osteoblastic sarcoma. As previously mentioned, it is extremely important in these early stages to take multiple roentgenograms of the site of involvement, with soft-tissue exposures as well as over-exposures. The extremity should be studied at the site of involvement in films taken every 30 to 45 degrees through its entire circumference. When the origin of the tumor is subperiosteal, it is unusual to identify cortical and medullary involvement in the early stages. When the origin is central, there may be little involvement of the cortex and no soft tissue mass until late stages. As the subperiosteal mass grows, a Codman reactive triangle may form and in every way resemble the triangles seen in osteoblastic sarcoma. Radiating spicules of sun-ray structure may be replaced by multiple islands of calcified cartilage, most evident in the older parts of the tumor. Such islands are more frequently small than large and give the mass a stippled appearance, as described by Phemister. On the other hand, the extracortical mass may contain little calcified cartilage, appearing roentgenographically as a homogeneous translucent mass.

As the subperiosteal mass enlarges, the presence of the tumor is more and more evident both clinically and roentgenographically, islands of calcification becoming more numerous and the Codman reactive triangle becoming sharply outlined. In most instances, the sun-ray structure, which may have existed in earlier stages, is gradually displaced, as perforation of the periosteum releases tumor cells into adjacent soft tissues. The peripheral border of the soft tissue mass is poorly outlined, having no boundary of calcification or ossification to demarcate it. Occasionally, a narrow rim of periosteal ossification exists temporarily at the outer border of the mass as a continuation of the Codman triangle, but such margins of reactive ossification are poorly formed and soon destroyed by the tumor itself. Reactive bone within the tumor seldom attains a significant distribution, and then only in early stages. Neoplastic ossification in a primary chondrosarcoma is a minor part of the picture, but occasionally there is scattered transformation of calcified cartilage to bone by direct metaplasia. Cross-section of the subperiosteal mass shows a multilobulated, glistening, pearly-gray tissue of firm, rubbery consistency, and a variable number of small cysts or pockets filled with brown fluid. The size of the tumor varies through a wide range, from minute proportions to many inches in diameter. The tissue is less vascular than that generally seen in osteoblastic sarcoma, but a few cases of a highly anaplastic form have been observed in which the vascularity and the degree of anaplasia made the tumor analogous to the osteolytic form of osteoblastic sarcoma.

Histologically cartilage is seen in all stages of differentiation. The usual sequence of events appears to be a transformation of fibroblasts to myxomatous tissue, myxomatous tissue to precartilage, and precartilage to cartilage (Fig. 9C). A wide variation in the size of the chondrocytes is an important characteristic of these tumors, pleomorphism and mitotic figures being the rule. No columnar or other purposeful arrangement of the chondrocytes can be identified. Fibrous septa separating the many lobes of the tumor are cellular. Numerous areas of myxomatous tissue, precartilage, and fetal cartilage with mitotic figures are of aid in differentiating chondrosarcomata from chondromata but it must be emphasized that histologically it is frequently impossible to distinguish between a growing chondroma and a chondrosarcoma. The myxomatous element is usually greater in a chondrosarcoma than in a chondroma.

Cortex: In early stages there may be no cortical involvement. If the origin is subperiosteal, roughening of the cortex, localized demineralization, and eventually

erosion are observed. A large circumscribed perforation in the cortical wall is often seen in chondrosarcoma, in contrast to the permeation that exists in osteoblastic sarcoma. Through a perforation of the cortex, usually metaphyseal, tumor tissue enters the subcortical region and there forms a rounded mass. Such a mass may contain little or no calcified cartilage and may appear in the roentgenogram as an area of pure destruction. Roentgenograms of these tumors should be taken in several planes if the perforation in the cortex is to be demonstrated. Pathological fractures are not common.

When central in origin, a chondrosarcoma may expand the cortex; it is the only type of osteogenic sarcoma associated with material cortical expansion. As expansion and internal cortical erosion occur, periosteal new bone forms to build up the cortex and, as long as possible, maintain its integrity and thickness. This gives rise to considerable irregularity peripherally, since the expansion and periosteal new bone do not form a smooth contour. These changes are observed most frequently in the upper femur.

Fig. 10 (above). Roentgenogram of a secondary chondrosarcoma developing in the cap of an osteochondroma of the lesser trochanter.

Fig. 11 (below). Photograph of a sagittal section of a secondary chondrosarcoma which developed in an osteochondroma of the upper humerus. The base of the osteochondroma is clearly visible just distal to the humeral head. This tumor, untreated for fifteen years, finally metastasized.

Subcortical Involvement: If the origin is subperiosteal, medullary involvement oc-

curs late and appears as a rounded central mass. When the origin is central, there may be extensive changes in the cancellous bone of the metaphysis, associated with considerable reactive bone, producing a complex picture of destruction and proliferation. Penetration of the epiphyseal plate does not occur as early or as regularly in primary chondrosarcoma as it does in osteoblastic sarcoma. In adults, extension of the tumor into the epiphysis occurs regularly, since there is no epiphyseal plate to resist the tumor's spread.

Secondary Chondrosarcoma (Figs. 10 and 11): Secondary chondrosarcoma represents a malignant transformation in the primitive fibrous tissue (mother tissue) of the perichondrium of an osteochondroma or a chondroma. More rarely a secondary chondrosarcoma may occur in chondrodysplasia, and a few cases have been described as occurring multicentrically in Paget's disease. Rarely seen before the twentieth year, these tumors have an age incidence extending from twenty to seventy years. A benign bone tumor seldom grows after full skeletal growth has been attained, and when such a tumor displays reactivation after the age of twenty, it should be considered as premalignant or actually malignant until proved otherwise. Of course, not all reactivated chondromata and osteochondromata are malignant; some have been removed incompletely and recurred several times before becoming malignant. Reactivation, however, must be viewed as evidence of potential malignancy and should lead to wide excision as early as possible.

It is not always easy to identify early malignant changes superimposed on an osteochondroma or chondroma. During adult life the cartilaginous cap of an osteochondroma is usually thin; when malignant transformation occurs the cap becomes much widened, while the periphery of the tumor is poorly defined and mottled by numerous islands of calcified cartilage. There is steady growth at the periphery, with little or no destruction of the base. Many such secondary chondrosarcomata have been allowed to grow over a course of many years, steadily advancing to large dimensions to invade surrounding soft tissue and eventually metastasize to the lungs. In most instances there is a long period of warning, a long period in which surgery may be successfully performed. It is to be regretted that closer observation of many of these tumors has not occurred in the past. This is one type of osteogenic sarcoma that can be successfully treated in the majority of cases, if only the treatment iscarried out at the proper time.

Chondromata undergoing transformation to secondary chondrosarcomata, are nearly always subcortical and are associated with expansion and destruction of the overlying cortex plus frequent pathological fracture. If a chondroma, or rather an enchondroma, is known to exist within one of the long bones or in the sternum, ribs, vertebrae, or pelvis, it should be watched throughout the life of the patient for reactivation that might mean transition to secondary chondrosarcoma. As has been previously stated, malignant transformation rarely occurs in chondromata of the hands and feet. Secondary chondrosarcoma has the best prognosis of any member of the osteogenic group, and the older the patient the better the prognosis. Radical resection, rather than amputation, is indicated in many cases. Signs of malignant transformation may be summarized as follows: reactivated growth, increasing pain, fixation of the tumor to overlying soft tissues, perforation of the cortex overlying the tumor, loss of definition of tumor margins, fuzziness within the tumor as seen in the roentgenogram, pathological fracture, increased vascularity in adjacent soft tissues, anaplasia among the chondrocytes, increasing myxomatous element, increased cellularity, pleomorphism and anaplasia in the peripheral part of the tumor beneath and in the perichondrium, and lastly hyperchromatism. No one of these signs can be taken by itself as indicative of malignancy, but when several or all of them become manifest, the diagnosis of malignant transformation should be made.

Little by little the long neglected subject of bone tumors is becoming organized, and is receiving the attention it deserves. We have been handicapped by inadequate and confusing material, and by a literature crowded with conflicting data. Although we are still burdened with widely divergent views, in general there is agreement on most of the basic concepts of bone tumors.

Differential diagnosis is often trying and difficult, made doubly so because so much is at stake. No other field commands more co-operation from roentgenologist, pathologist, and clinician. Let each in his field assume his share of the responsibility, and let him learn as much as possible about, not one, but all of the many aspects of this important and fascinating subject. It is by earnest study and co-operation that new vistas will be opened to us—vistas that can be interpreted in terms of real benefit to the patient.

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GENERAL DISCUSSION OF SYMPOSIUM ON BONE TUMORS

(Papers by K. O. Haldeman, M.D., and J. Vernon Luck, M.D.)

Question: What does Doctor Haldeman think of the theory that an osteochondroma arises in cases of developmental displacement of the tendons?

Doctor Haldeman: Osteochondromas characteristically occur on bones at the site of attachment of tendons. This is illustrated by the pictures which we saw of the osteochondroma arising from the lower end of the femur at the point of attachment of the adductor tendons. I believe that they probably occur elsewhere as well. The explanation of their occurrence at the point of tendon attachment lies in the fact that periosteum is deficient at that site, and, of course, the periosteum is a restraining membrane of growing bone. An additional factor is the possible occurrence of cartilaginous cells at the insertion of the tendon into bone. The presence of such cells has been described by Geschickter and Copeland, who show microscopic sections in support of their hypothesis. The theory is somewhat disputed by other authors, but the fact remains that this is the common site of occurrence of the osteochondromas.

Question: What is your theory of the production, in animals, of osteogenic sarcoma in the shafts of long bones by the injection of certain irritating substances?

Doctor Haldeman: A discussion of neoplastic formations in experimental animals would carry us far off our track. It has, of course, been shown that the hereditary factor in rats, as regards tumor formation, is very strong, but these conclusions have not been successfully applied to the study of human carcinoma and sarcoma. Many methods have been employed to produce sarcomas and carcinomas experimentally in animals, but the connection between experimental malignant growth and the spontaneous occurrence of malignant tumors in man is still a matter of dispute.

Doctor Bromer has raised the question [see p. 251] whether this type of tumor arises at the transition of cartilage into bone. He points out that the picture is not constant in Group 1, in which occur the osteochondromas and the myxosarcomas. It is true that there is a great variation in the type of tumor which is produced in this connective tissue. In certain cases of osteoplastic osteogenic sarcomas there is a considerable amount of bone repair which may resemble callus. As a general rule, however, the malignant tumors do not show the formation which is characteristic of callus. We have found, in some of these sarcomas, masses of cells without bone trabeculae. In general, I would say that the bone tumor cells do not resemble the normal cell. Jacobson, in the *American Journal of Cancer* for November 1940, published an article in which he showed the inter-relationship of tumor formation and pointed out that bone tumors arise from an embryonic cell which is differentiated into a spindle cell. The spindle cell then takes one of three directions: it may form an osseous tumor, or it may be transformed into a cartilaginous tumor, or it may be transformed into a malignant connective-tissue tumor. Microscopic sections of these tumors indicate their close relationship to embryonic tissue rather than to reparative callus.

I would like to make a comment on Doctor Luck's discussion of osteoid osteoma. Several years ago Doctor Jaffe described what he called an osteoid osteoma, and recently he gave an excellent paper in which he showed a series of some 15 or 20 cases of osteoid osteoma. The cases which he presented would by most of us be called chronic sclerosing osteitis, or the osteomyelitis of Garré. Fifteen years ago I was much interested in osteomyelitis of Garré and gathered considerable material but was never able to answer certain questions which arose in that connection. Doctor Jaffe's theory that this is an osteoid osteoma—in other words, that it is a benign neoplasm rather than an inflammatory process—would help to answer some of those questions. On the other hand, almost all stages of transition are found from chronic osteomyelitis through Brodie's abscess up to this condition of non-suppurative osteomyelitis, or chronic sclerosing osteitis, which has been described by Henderson. As has been pointed out, in the most chronic type of bone infection all the inflammatory elements, such as round cells, have

disappeared. I think we should postpone a final acceptance of Jaffe's theory of osteoid osteoma until further evidence is submitted.

Question: Why is osteogenic sarcoma reluctant to pass across the cartilaginous elements of the epiphysis?

Doctor Luck: There is no tissue in the body that offers so great a barrier to tumor cells as calcified cartilage. The reason for that is not clear. But there is one thing that might be said in explaining some of the sections that were shown in which tumor cells were seen piling up against the calcified cartilage and remaining there, waiting a long time before they succeeded in passing through. The tumor tissue there is moving along the line of least resistance. Since the trabeculae many times are small, it finds a much better avenue of spread through the inter-connecting marrow spaces than it does against the solid barrier of calcified cartilage. For a time, therefore, it moves along until the spaces next to the plate are pretty much filled. Then, having no further area to invade in the cancellous bone, it moves against the epiphyseal plate and, of course, as you saw, eventually succeeds in breaking through it.

Question: How can you differentiate fibrosarcoma of bone with intact cortex from sclerosing osteomyelitis?

Doctor Luck: There are several good points by way of differential diagnosis. In the first place, the sclerosing osteomyelitis, when and if it occurs—and it isn't so common as we formerly thought—occurs more in the diaphysis around cortical bone, whereas the fibrosarcoma is far more common in cancellous bone of the metaphysis. This is an important point. Sclerosing osteomyelitis forms periosteal new bone. The thickened cortex, its denseness, and the smoothness of its peripheral contour are all points which characterize sclerosing osteomyelitis. In contrast, fibrosarcoma occurs either centrally or peripherally and, if it occurs peripherally in the periosteum or adjacent to the periosteum, we see it eroding the cortex.

John T. Murphy, M.D. (Toledo, Ohio): In connection with the subject of fibrosarcoma apparently arising in the cortex of the bone, I may cite a case in a child in which the fibrous tissues were so similar and the arrangement of the cells so irregular that the pathologist interpreted the condition as fibrosarcoma. I believe that it was simply a low-grade infection, probably subsequent to injury. The picture is exactly the same as that produced by the tumors that do not invade the bone. I may not be right in the statement that they do not invade; they cause an effect by pressure, more or less.

Doctor Luck: They do not invade in the sense that carcinoma might invade a bone, but on studying the junction between the tumor and the cortex, we see that the tumor is not destroying the bone entirely by pressure but is actually permeating it. And we see another thing that is interesting. At the outset the bone is a dense structure with very small haversian and Volkmann canals, but with the increased hyperemia that is brought in by the tumor we see the compact bone in the invaded area undergoing transformation to cancellous bone. That is an important point, because then we see enlarged avenues of entrance by which the tumor can permeate, thus permitting its ready access and eventual introduction into the spongy bone of the metaphysis. Once it gets there, it has a satisfactory avenue for extension throughout a large area.

Ralph S. Bromer, M.D., (Bryn Mawr, Penna.): The disease process known as multiple cartilaginous exostoses is closely related to multiple enchondromata. It has been observed that the enchondromata do not increase in size when the full growth of the patient is obtained. They have been considered by some as neoplasms, by others as a growth disturbance. Bentzon crushed the dorsal sympathetic nerves in rabbits and was able, he stated, to produce an enchondromatous lesion in the metatarsal. He advanced the theory that the bone changes in this condition were due to disturbance of the vascular supply to the bone.

I would like to ask Dr. Haldeman whether he considers that these lesions are actual neoplasms or whether they are to be regarded as a disturbance of growth not related to neoplastic formation?

Doctor Haldeman: The cases which are seen are characterized by the presence of other deformities, as inequality in the length of the legs or abnormal shortness of stature. I believe, therefore, that dyschondroplasia is a disturbance of growth and differs from the usual osteochondroma.

Doctor Luck: I think that from the standpoint of histopathology there is no difference between multiple hereditary cartilaginous exostoses and a solitary osteochondroma. They have exactly the same histological structure and they undergo the same changes in growth that occur in a single osteochondroma. Multiple lesions, however, may, of course, cause growth disturbances; the whole entity appears to represent a disturbance in enchondral ossification.

The Roentgenologic Pattern of the Small Intestine in Infants and Children[1]

HENRY ZWERLING, M.D.,[2] and WALDO E. NELSON, M.D.

In recent years there have been described variations in the roentgenologic pattern of the small intestine which have been considered to be characteristic of certain nutritional deficiency states. According to May and McCreary (1) "clumping" in roentgenograms of the small intestine of infants and children with the celiac syndrome was noted by Blackfan and Vogt as early as 1930. Apparently the first published report was that of Mackie (2), who in 1933 described certain functional changes in the roentgenologic pattern of the small intestine in a patient with non-tropical sprue. Subsequently, essentially similar observations have been made in such clinical conditions as steatorrhea in adults (3), infantile celiac syndrome (4), acholia (5), chronic ulcerative colitis (6), tropical sprue (7), hypocalcemia (8), nephrosis and diabetes insipidus (9). Such changes have also been noted in the roentgenograms of the intestines of dogs with hypoproteinemia produced by plasmapheresis (10). Golden (11) has pointed out that a similar intestinal pattern is observed in normal new-born infants; he has suggested that the transition from the "infantile" to the "adult" pattern occurs at four to five months of age. Recently Mackie (12), Golden (13), and Lepore and Golden (14) have been inclined to attribute this abnormal intestinal pattern, which has been noted in a variety of clinical conditions, to a deficiency of the vitamin B complex.

Doubt that intestinal patterns of the type described are necessarily indicative of abnormalities in children beyond the age of infancy was raised when a presumptive diagnosis of the celiac syndrome was made on the basis of roentgenologic studies of the small intestine in several children who had no clinical manifestations of the disease. For this reason, it was decided to study the small intestine in healthy infants and children to determine, if possible, the type of roentgen pattern to be expected and to determine if there is a definite chronologic transitional period at which there occurs a change from the "infantile" to the "adult" pattern.

METHOD

Seventy-seven infants and children, ranging in age from three months to eleven years, were studied. Twenty were infants chosen from the well-baby clinic on the basis of an average developmental and nutritional status; 45 were from an orphanage[3] and ranged in age from four to eight years. The orphanage children received, in addition to their regular diet, supplementary vitamins, as Vi-Penta and Oleum percomorphum. The remaining 12 children, from one to eleven years of age, were from families in good economic circumstances. With one exception, all of this last group were in good nutritional condition.

After an overnight fast the children were given 1 to 2 ounces of a barium-water mixture, the amount varying within this range with the size of the child. In children over one year of age, equal parts of plain barium sulfate and boiled tap water were employed. For infants, 3 parts of water to 2 parts of barium were used in order to obtain a mixture which would flow readily through the holes of a nipple.

[1] From the Department of Roentgenology and the Department of Pediatrics of the Temple University School of Medicine. Aided by a grant from the Ann Chamberlain Research Fund. Presented before the Society for Pediatric Research at Skytop, Penna., April 30, 1942. Accepted for publication in September 1942.

[2] Roentgenologist at Highland, Alameda County Hospital, Oakland, Calif.

[3] We are indebted to the Catholic Home for Destitute Children for their splendid co-operation.

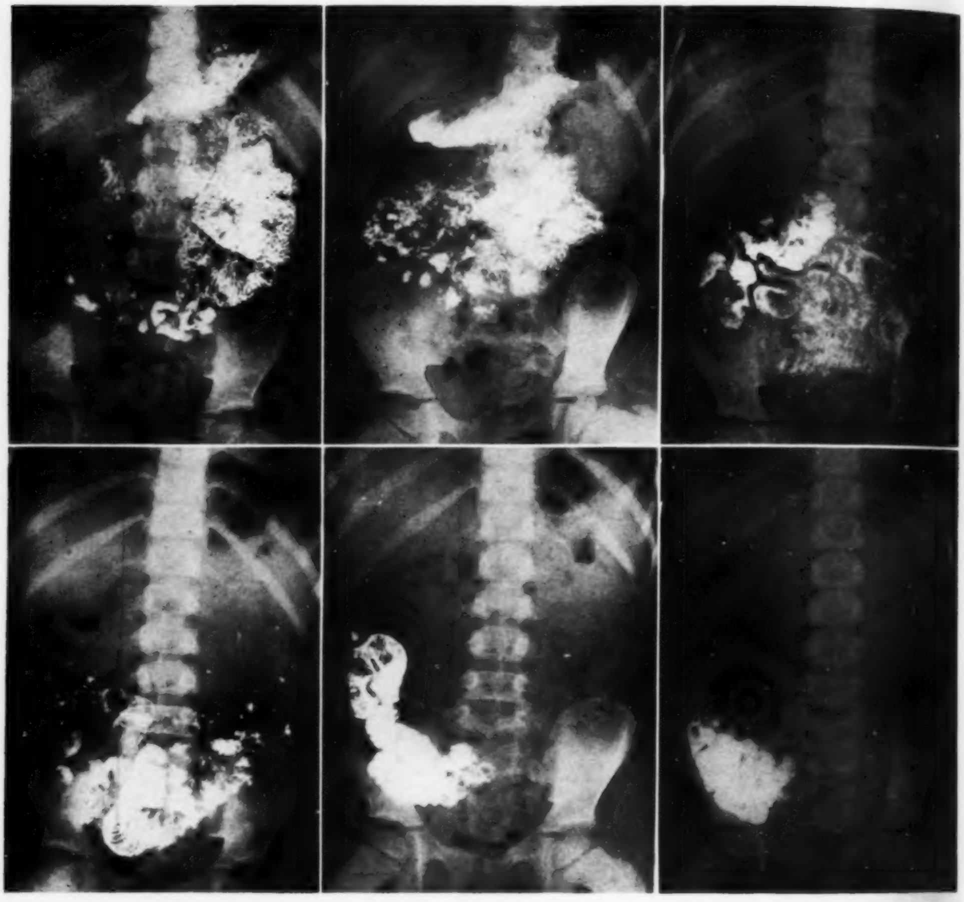

Fig. 1. "Normal adult pattern" in a boy, 5 years of age, who has a nutritional deficiency. This demonstrates the progress of the barium through the small intestine in one continuous stream. The slight segmentation noted in the left lower film is not considered unusual. Mucosal markings are regular.

Roentgenograms were taken thirty minutes after the ingestion of the barium and at intervals of thirty to sixty minutes until the barium had progressed to the distal ileum or to the cecum. Since it was not planned to study the terminal ileum, "compression films" of this area were not obtained. In the earlier part of the study fluoroscopic examinations were performed before the exposure of each film, but this was abandoned since additional information was not obtained by the procedure, and the darkness of the fluoroscopic room appeared to cause some fear and emotional disturbance.

DISCUSSION OF OBSERVATIONS

In the roentgenologic pattern of the healthy adult the barium is observed in a continuous stream, and there is a regularity of the mucosal markings. There are no marked variations in the caliber of the lumen except for areas of narrowing where peristalsis is active. Flocculation is of the powdery, even type, and the barium enters the distal ileum or cecum in an hour and a half to six hours. This type of pattern is illustrated in Figure 1. It is of more than passing interest that these roentgenograms are those of the one child

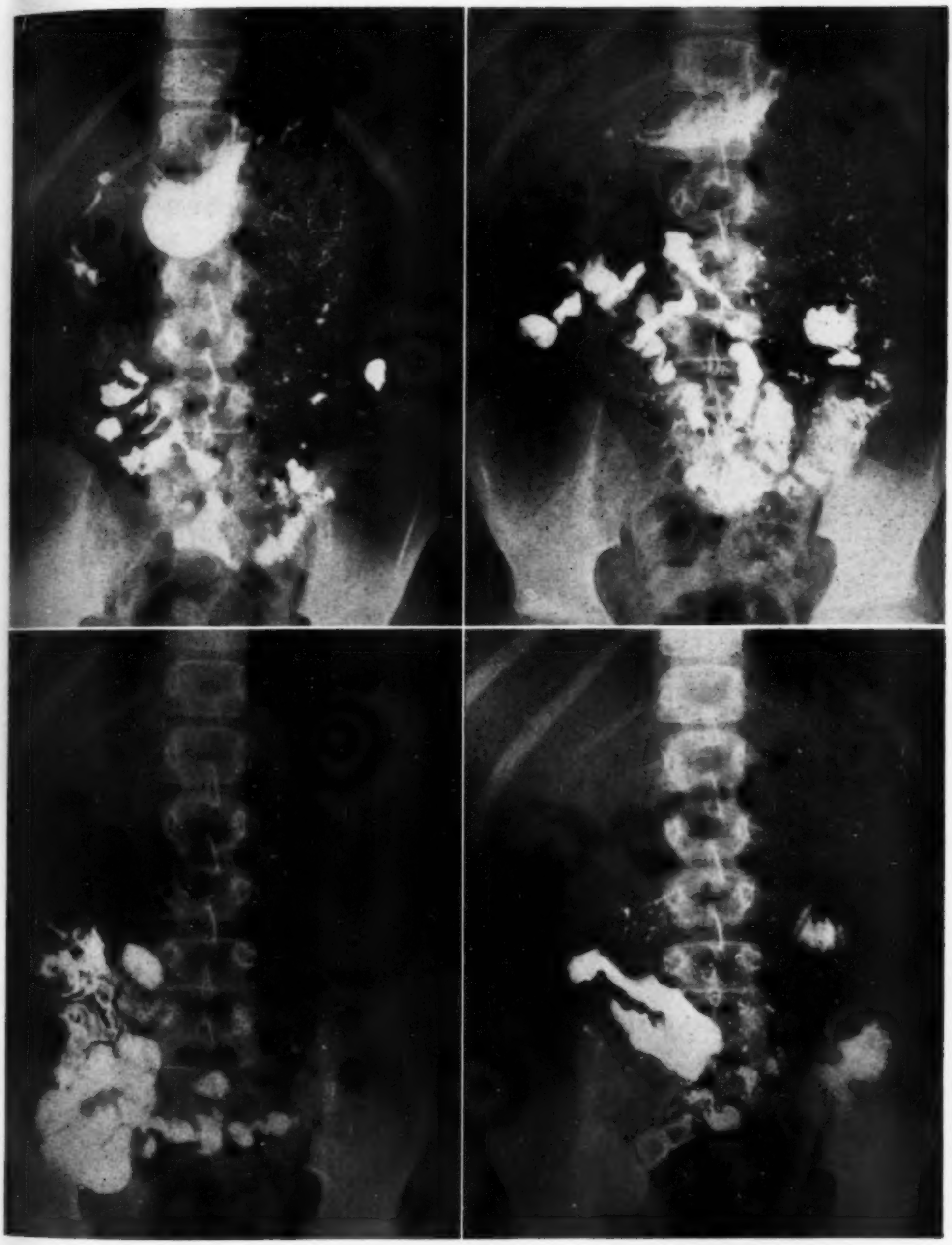

Fig. 2. "Abnormal pattern" in a healthy girl, 9 years of age. In the upper left roentgenogram (one-half hour film) there are marked segmentation, irregular flocculation, and coarsening or obliteration of mucosal markings. Similar findings are observed in the other films of the series, and hypertonicity (string-like quality) of many loops is demonstrated.

Fig. 3. Pronounced hypertonicity resulting in shadows which resemble multiple strings in a healthy infant, 6 months of age.

in the series who had a definite nutritional disturbance.

In the deficiency states the roentgenologic changes which have been described consist of coarsening or obliteration of the mucosal markings, segmentation, irregular flocculation, and in some instances dilatation. The pattern in gastro-intestinal allergy is that of hypertonicity with narrowing of the lumen, which is especially marked in the lower one-third of the small intestine. The films at one-half hour or at one hour may reveal a normal pattern, whereas the later films may show abnormalities.

In this series of apparently healthy children all of the above signs except dilatation were encountered in the majority of instances (Figs. 2 and 3). So-called normal "adult" patterns were distinctly rare, being observed in only 5 of the 77 children; the earliest age at which such a pattern was observed was eleven months. So-called "infantile" or "deficiency" patterns were observed in 38 infants and children. The remainder of the group showed patterns which could be interpreted as being transitional between the "infantile" and "adult" types. Thus, if the present criteria for the "normal" small intestine were employed in the interpretation of the roentgenograms in this series of children, the majority of them would be considered as having a nutritional deficiency. For comparison, the roentgenograms of the small intestine of a girl, three years of age, who has typical celiac disease are shown in Figure 4. It will be noted that the differences between the patterns illustrated in Figure 2 and Figure 4 are essentially of degree only. The child whose roentgenograms are shown in Figure 2 is a healthy girl, nine years of age.

While more complete studies, especially of vitamin B metabolism, are required to determine the nutritional status of these children, it would not appear justifiable to consider them as abnormal on the basis of the roentgenologic evidence. Among the factors which must be considered to explain the observed intestinal patterns are emotional disturbances. While we do not have sufficient evidence to answer this question, we do have repeated studies on 5 children. In 3 of these there was distinctly less manifestation of emotional upset at the time of the second examination. The intestinal patterns of these children were essentially the same at each examination.

It cannot be concluded from these observations that there are not deviations from the usual in the roentgenologic pattern of the small intestine of infants and children who have a nutritional disturbance such as the celiac syndrome or one of a less obvious clinical nature. These preliminary data, however, are evidence that more complete studies of the factors which affect the roentgenologic intestinal pattern of infants and children must be obtained before this type of examination is employed as a measure of nutritional status.

SUMMARY

In the roentgenologic study of the small intestine in 77 presumably normal infants and children wide variations in the pattern

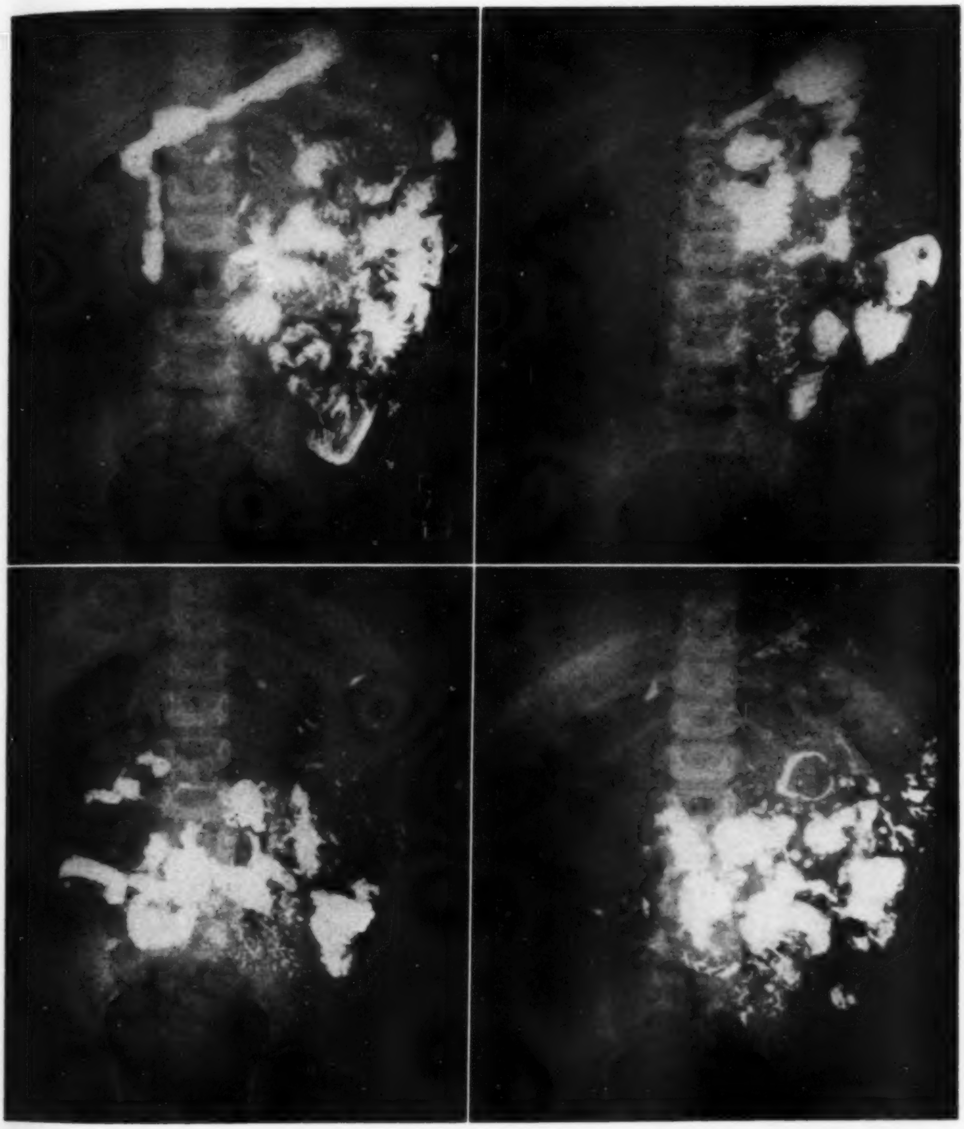

Fig. 4. Intestinal pattern in a girl, 3 years of age, who has celiac disease. There are coarsening or obliteration of mucosal markings, segmentation, irregular flocculation, and a few areas of hypertonicity. Note the lack of curvature of the duodenal loop in the upper left. This may have significance, since the pancreatic enzymes empty into this portion of the duodenum.

have been observed. On the basis of these data it would appear that the roentgenologic appearance of the small intestine is not at the present time a reliable criterion for the diagnosis of nutritional deficiency states.

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Quality, Area, and Distance Relationship for D_5, D_{10}, and D_{15}. I

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SINCE THE addition in 1940 of a million-volt and a 400,000-volt x-ray generator to the therapy department of the State Institute for the Study of Malignant Diseases (New York), which had previously worked with voltages not exceeding 200,000, numerous depth dose measurements have been made over a wide range of qualities. The availability of these generators for purposes of depth measurements was definitely limited, and it was felt that the sporadic individual measurements made at widely scattered times to meet the immediate needs of the department did [not yield results as satisfactory as might be desired.

It was decided, therefore, to assemble all the depth measurements[2] made at this Institute during the past several years, together with published depth intensities of other authors, and endeavor to establish a relationship between depth intensity and field size, quality, and distance so as to permit a simple conversion of depth intensity for one set of conditions of area, quality, and distance to another.

During the process of organizing the data

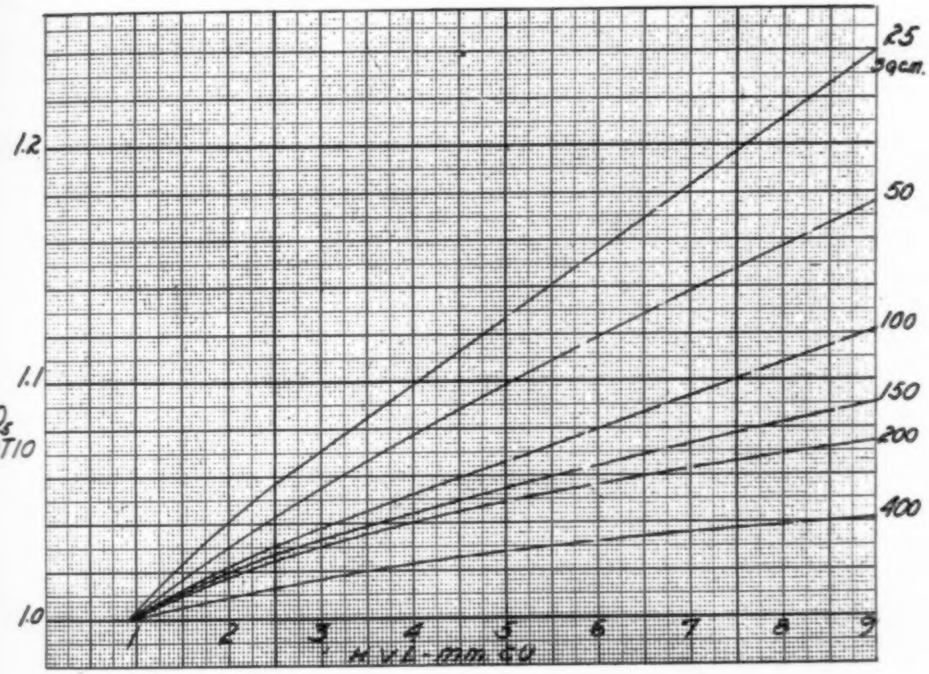

Fig. 1. Quality ratio curves for D_5.

[1] From the State Institute for the Study of Malignant Diseases, Buffalo, New York. Burton T. Simpson, M.D., Director. Paper accepted for publication in September 1942.

[2] It has been impossible to include the tabulated data because of its large volume.

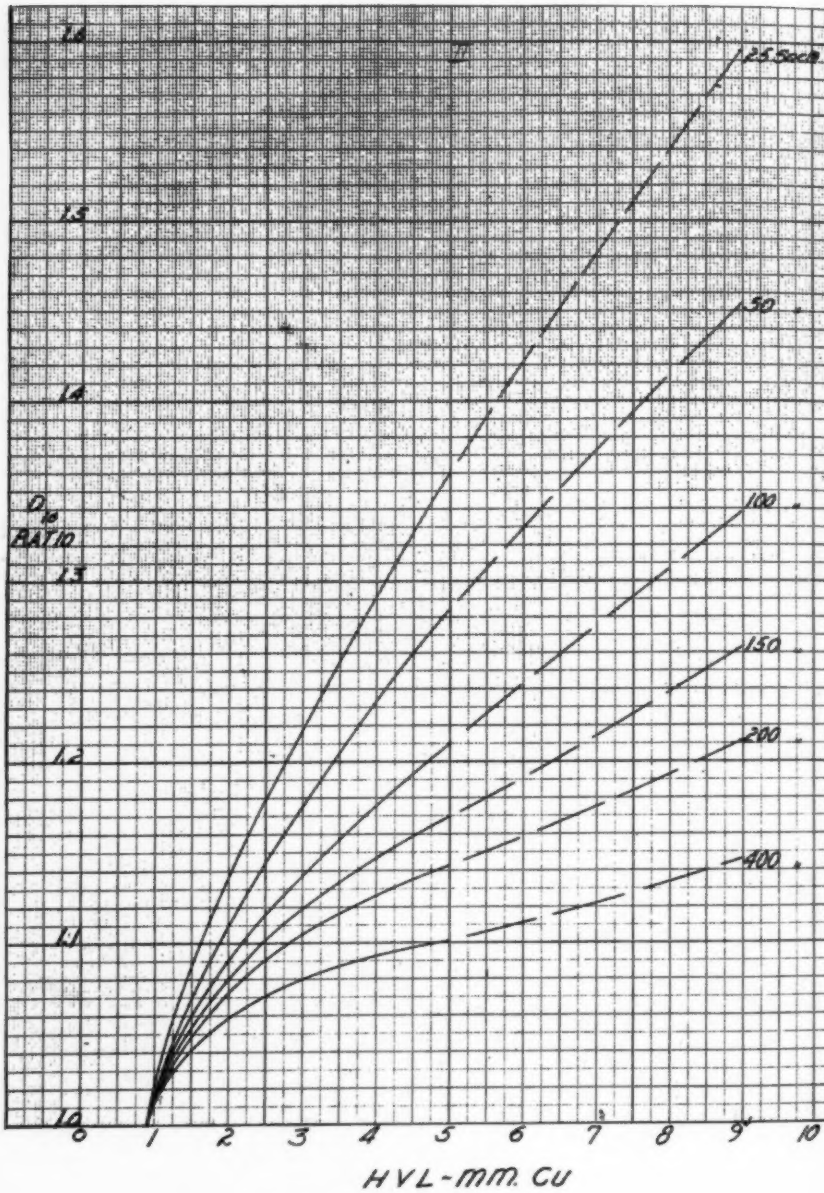

Fig. 2. Quality ratio curves for D_{10}.

and prior to the writing of this paper, articles were published by Quimby (9) and Mayneord and Lamerton (5) covering much of the same type of information which we were obtaining from our own measured data. Both of these publications were of value in the organization of our data.

In order to translate depth intensities from one set of conditions to another, it was decided to express the transition by a series of ratio curves, which provide a

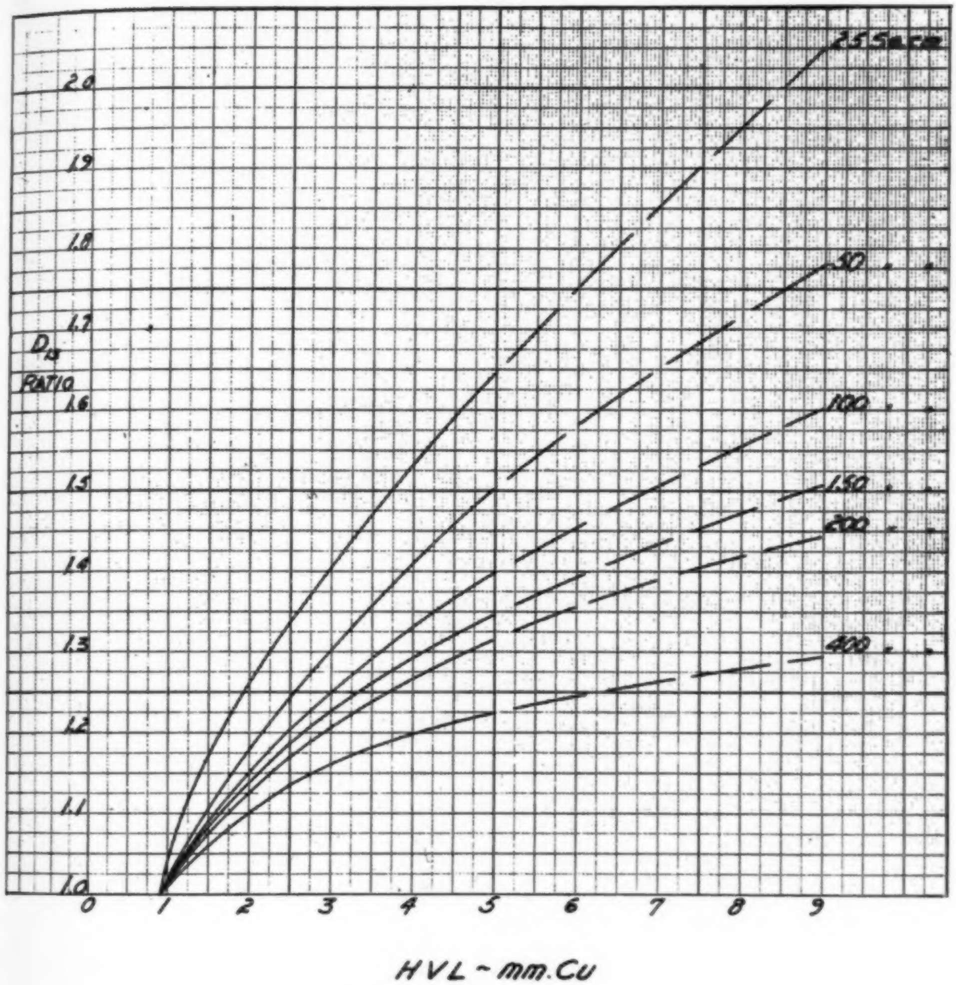

Fig. 3. Quality ratio curves for D_{15}.

quick and easy method of converting a known depth intensity for one set of conditions to any other set of conditions of area, quality, and distance. A plot of the four points, surface (D_0),[3] 5 cm. depth (D_5), 10 cm. depth (D_{10}), and 15 cm. depth (D_{15}) permits a fairly accurate depth curve to be drawn. We have therefore limited our ratio curves to D_5, D_{10} and D_{15}.

[3] D_0 is considered as 100 per cent dose on the surface with tissue back-scattering. Mayneord and Lamerton (5) give an extensive table of back-scattering values for a wide range of wave lengths and field sizes.

QUALITY RELATIONSHIP

A study of the assembled depth measurements indicated that the relationship between quality in half value layer (H.V.L.) mm. of copper and D_5, D_{10}, and D_{15} could be expressed as a simple ratio for each depth and one field size in square centimeters. Thus a family of quality curves ranging from 0.9 to 9.0 mm. copper H.V.L. was established, covering areas 25, 50, 100, 150, 200, and 400 sq. cm. for D_5, another for D_{10}, and a third for D_{15} (see Figs. 1–3). By maintaining a constant field size and dis-

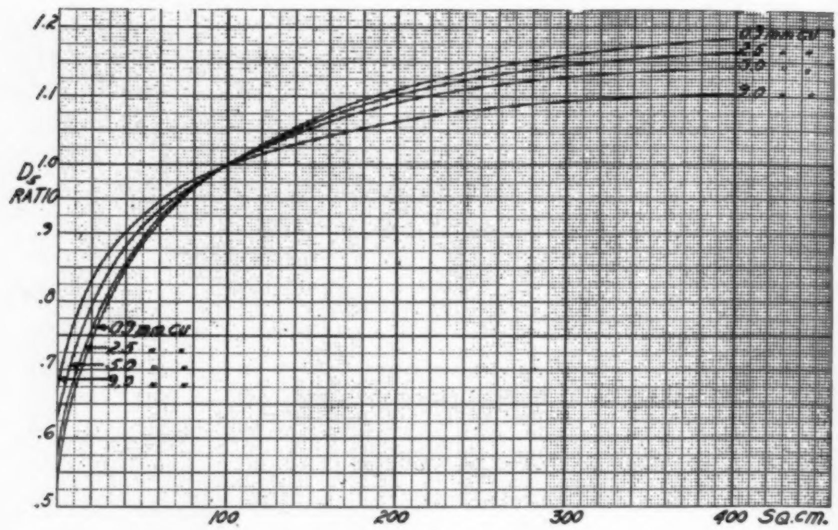

Fig. 4. Area ratio curves for D_5.

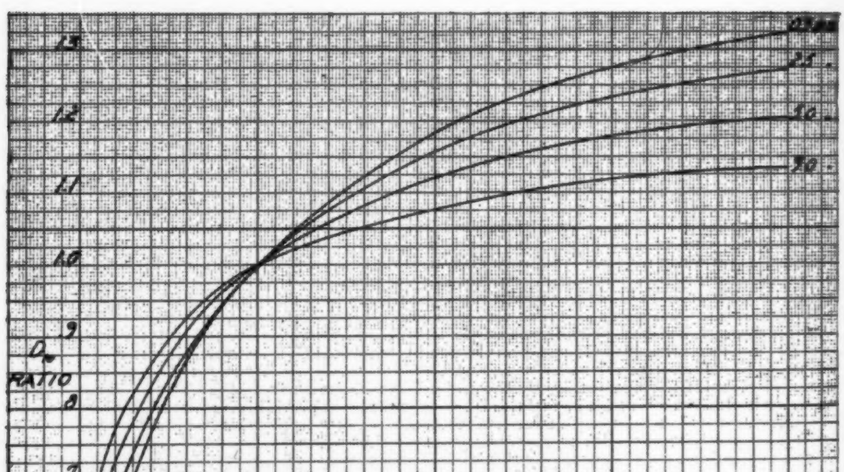

Fig. 5. Area ratio curves for D_{10}.

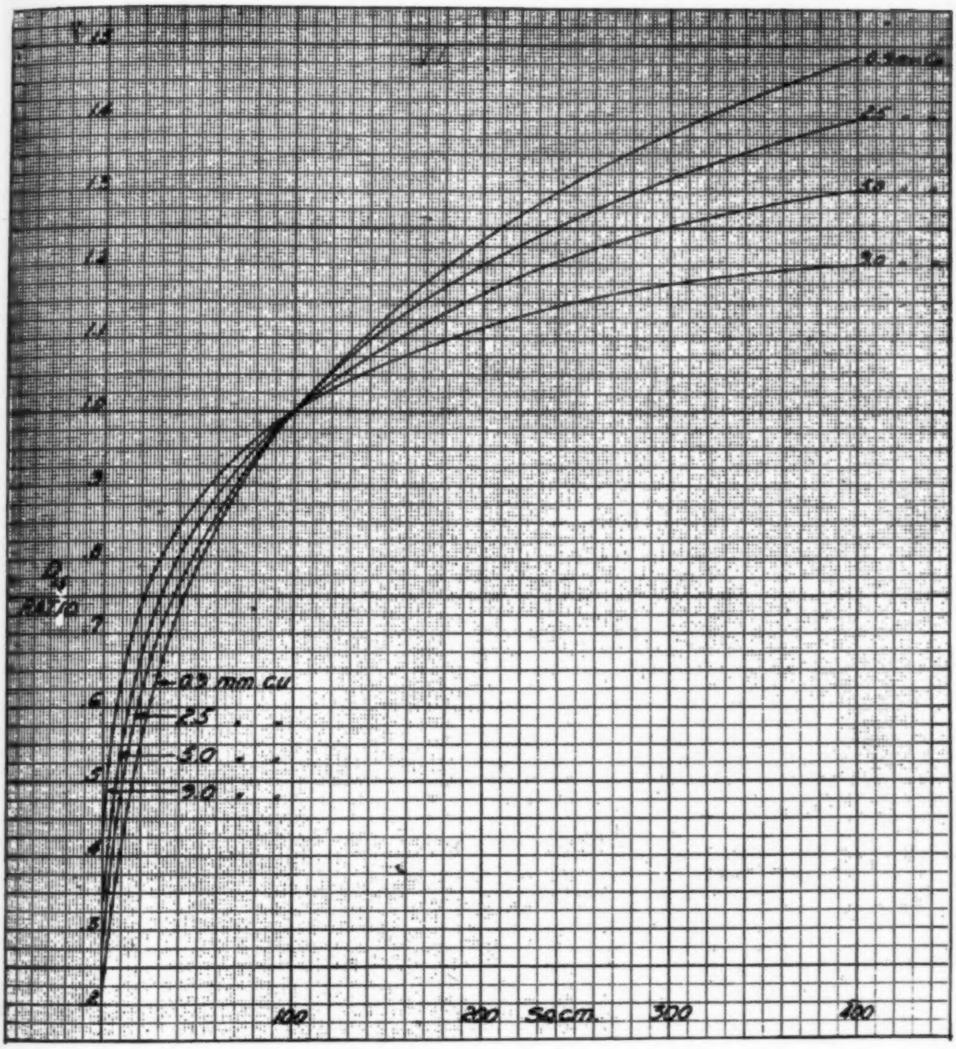

Fig. 6. Area ratio curves for D_{15}.

tance, it is possible by means of these curves to translate the depth values from one quality to another. It is interesting to note that the ratio increases more rapidly in the smaller areas than in the larger areas for the range of qualities under discussion. This is an indication that the advantages of higher voltages are more significant with smaller treatment areas.

In order to show the manner in which the quality ratio curve may be used, let us suppose, for example, that a radiologist has been treating with a beam of x-rays having a H.V.L. of 1.1 mm. copper, established by the original calibration, with a field of 200 sq. cm., and that he has been using a table of depth intensities for a 70 cm. focal distance. Suppose further that he wishes to use a harder beam, such as 2.5 mm. copper H.V.L., but has no information concerning depth values for the new quality and 70 cm. distance. He may obtain

the complete depth curve for the new quality by (1) determining the factor relation ship between the old and the new quality for that field size from Figures 1–3, that is for D_5, D_{10}, and D_{15}; (2) calculating the new D_5, D_{10}, and D_{15} values; (3) plotting these values obtained by calculation on semi-log paper and drawing a smooth curve.

TREATMENT AREA RELATIONSHIP

A further study of the tabulated data mentioned previously showed that a ratio could be established between treatment area and D_5, D_{10}, and D_{15} for each quality. The area relationships of the various qualities—0.9, 2.5, 5.0, and 9.0 mm. cop-

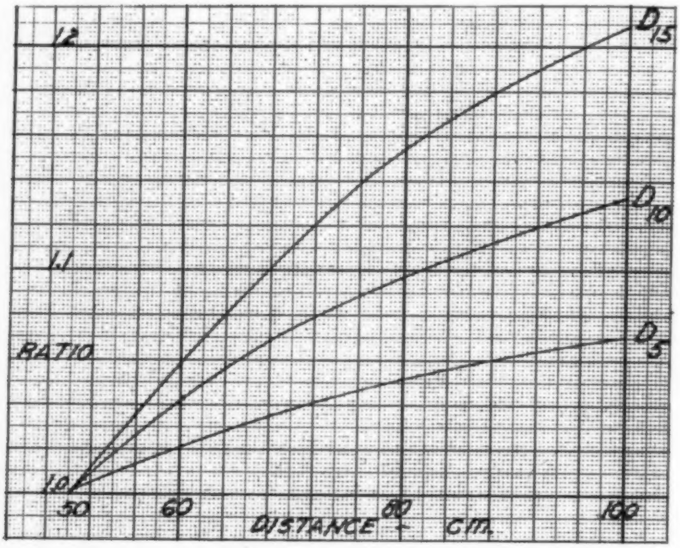

Fig. 7. Distance ratio curves for D_5, D_{10}, and D_{15}.

The factor relationship for a 200 sq. cm. treatment area obtained from the curve for D_5 is

$$\frac{1.0038 \text{ for } 1.1 \text{ Cu}}{1.024 \text{ for } 2.5 \text{ Cu}} = \frac{D_5 \text{ I for } 1.1 \text{ Cu}}{D_5 \text{ I for } 2.5 \text{ Cu}}$$

for D_{10} is

$$\frac{1.022 \text{ for } 1.1 \text{ Cu}}{1.093 \text{ for } 2.5 \text{ Cu}} = \frac{D_{10} \text{ I for } 1.1 \text{ Cu}}{D_{10} \text{ I for } 2.5 \text{ Cu}}$$

for D_{15} is

$$\frac{1.03 \text{ for } 1.1 \text{ Cu}}{1.17 \text{ for } 2.5 \text{ Cu}} = \frac{D_{15} \text{ I for } 1.1 \text{ Cu}}{D_{15} \text{ I for } 2.5 \text{ Cu}}$$

where I = relative depth intensity.

There is the possibility that the radiologist might wish to use a field size with the 2.5 mm. copper H.V.L. for which he had no previous information. This problem will be discussed under Area Relationship.

per H.V.L.—for D_5, D_{10}, and D_{15} are shown in Figures 4–6, where the value for 100 sq. cm. is used as unity. The ratio figures for the zero area were obtained by calculating the depth intensity as a function of distance and absorption. The absorption coefficients for water which were used are as follows:

H.V.L. mm. Cu	μ H_2O
0.9	0.183
2.5	0.158
5.0	0.134
9.0	0.11

The absorption coefficient of 0.11 for the million-volt generator (H.V.L. 9.0 mm. copper) was obtained from a curve published by Tuve (13) for a frequency of radiation of 500 equivalent kilovolts. With the distance and quality kept constant, the area ratio curves provide a simple means

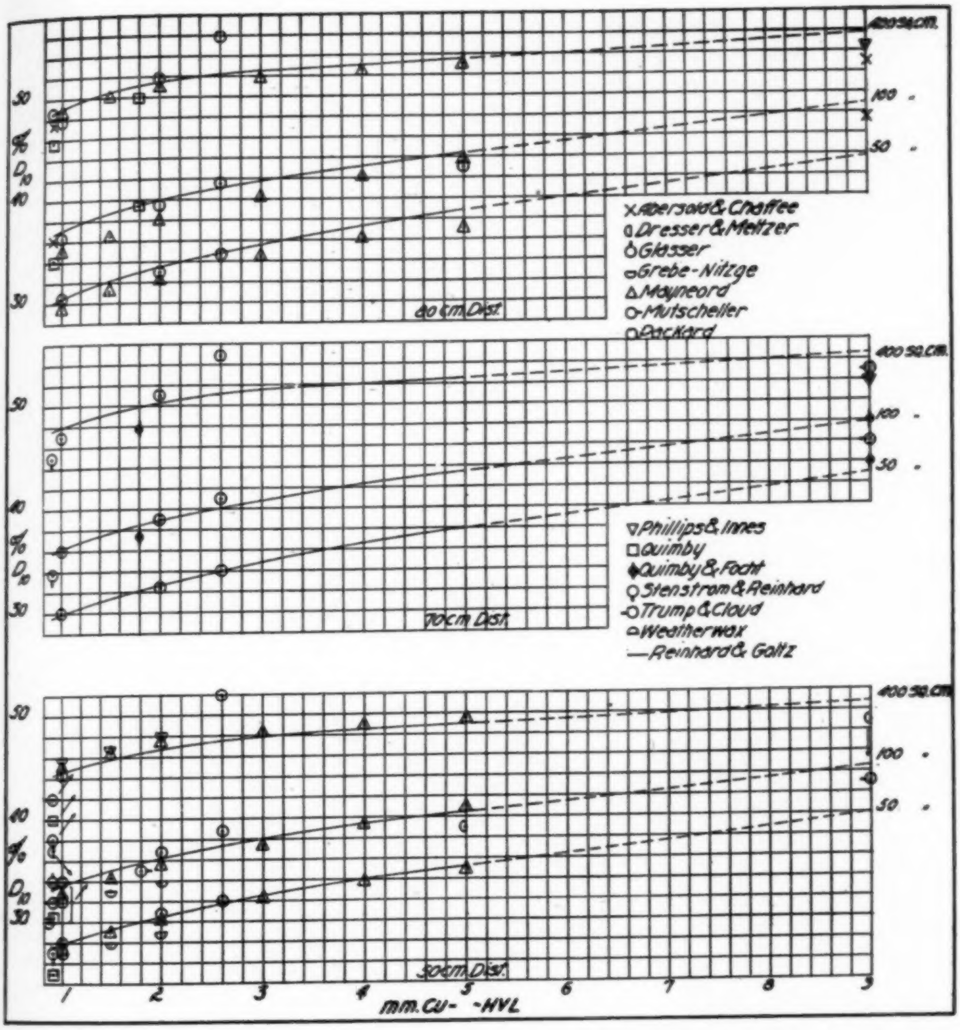

Fig. 8. D_{10} values plotted against half value layer in mm. copper, with published values of other authors as indicated.

of translating the depth intensity from one field size to another.

Following the example cited above (p. 287) one step further, let us suppose that the radiologist deems it advisable to use a smaller treatment area, *e.g.*, 80 sq. cm. for the harder radiation at 70 cm. distance, instead of his customary 200 sq. cm. field at the same focal distance, but he has no depth-dose information for the 80 sq. cm. field. It has been shown by what method he could arrive at the D_5, D_{10}, and D_{15} intensity values for the 200 sq. cm. field but with different quality. In order to determine the depth intensities for an 80 sq. cm. area at the new quality, the ratios are read from the 2.5 copper curves of Figures 4–6, as follows:

From Figure 4

$$\frac{\text{80 sq. cm. area } 0.97}{\text{200 sq. cm. area } 1.092} = \frac{D_5 \text{ I for 80 sq. cm.}}{D_5 \text{ I for 200 sq. cm.}}$$

TABLE I: DEPTH-DOSE CALCULATIONS FOR VARIOUS QUALITIES, AREAS, AND DISTANCES

	25 sq. cm.	50 sq. cm.	100 sq. cm.	150 sq. cm.	200 sq. cm.	400 sq. cm.
			H.V.L. 0.9 mm. Copper			
			50 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	49.0	56.0	63.2	67.4	70.2	75.0
D_{10}	22.5	27.5	33.4	37.0	39.6	44.3
D_{15}	10.0	13.2	16.6	18.9	20.5	24.7
			60 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	50.0	57.2	64.6	68.8	71.7	76.6
D_{10}	23.5	28.7	34.8	38.6	41.3	46.2
D_{15}	10.7	14.0	17.6	20.0	21.7	26.1
			70 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	50.9	58.2	65.6	70.0	72.9	77.9
D_{10}	24.2	29.6	35.9	39.8	42.6	47.6
D_{15}	11.2	14.8	18.5	21.0	22.8	27.4
			80 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	51.6	58.9	66.5	70.9	73.9	78.9
D_{10}	24.7	30.2	36.7	40.6	43.5	48.6
D_{15}	11.7	15.3	19.2	21.8	23.7	28.5
			100 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	52.4	59.9	67.6	72.15	75.1	80.3
D_{10}	25.5	31.2	37.8	41.9	44.9	50.2
D_{15}	12.2	16.0	20.1	22.8	24.8	29.8
			H.V.L. 2.5 mm. Copper			
			50 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	51.8	58.4	65.2	69.3	71.9	76.0
D_{10}	26.5	31.5	37.3	40.8	43.3	47.5
D_{15}	13.5	16.4	20.0	22.4	24.0	28.0
			60 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	52.9	59.6	66.6	70.8	73.4	77.6
D_{10}	27.6	32.8	38.9	42.5	45.1	49.5
D_{15}	14.3	17.4	21.2	23.7	25.4	29.6
			70 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	53.8	60.6	67.7	72.0	74.7	79.0
D_{10}	28.5	33.9	40.1	43.9	46.5	51.1
D_{15}	15.0	18.2	22.2	24.9	26.7	31.1
			80 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	54.7	61.4	68.6	72.9	75.6	80.0
D_{10}	29.1	34.6	41.0	44.8	47.5	52.2
D_{15}	15.6	19.0	23.1	25.9	27.7	32.4
			100 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	55.4	62.5	69.8	74.2	76.9	81.3
D_{10}	30.0	35.7	42.3	46.2	49.1	53.8
D_{15}	16.3	19.9	24.2	27.1	29.0	33.9

From Figure 5

$$\frac{\text{80 sq. cm. area } 0.946}{\text{200 sq. cm. area } 1.073} = \frac{D_{10}\text{ I for 80 sq. cm.}}{D_{10}\text{ I for 200 sq. cm.}}$$

From Figure 6

$$\frac{\text{80 sq. cm. area } 0.938}{\text{200 sq. cm. area } 1.063} = \frac{D_{15}\text{ I for 80 sq. cm.}}{D_{15}\text{ I for 200 sq. cm.}}$$

DISTANCE RELATIONSHIP

Quimby reports that the variation in depth intensity with distance may be calculated by means of the inverse-square law. Mayneord, on the other hand, claims that the depth doses show less variation with distance than predicted by this law.

TABLE I: DEPTH-DOSE CALCULATIONS FOR VARIOUS QUALITIES, AREAS, AND DISTANCES (*Continued*)

	25 sq. cm.	50 sq. cm.	100 sq. cm.	150 sq. cm.	200 sq. cm.	400 sq. cm.
			H.V.L. 5.0 mm. Copper			
			50 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	55.2	61.5	67.4	71.1	73.6	77.1
D_{10}	30.6	35.3	40.4	43.3	45.3	48.8
D_{15}	16.6	19.8	23.2	25.4	27.0	30.2
			60 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	56.4	62.8	68.8	72.6	75.2	78.8
D_{10}	31.9	36.8	42.1	45.1	47.2	50.8
D_{15}	17.6	21.0	24.5	26.9	28.6	32.0
			70 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	57.4	63.9	70.0	73.8	76.4	80.1
D_{10}	32.9	38.0	43.4	46.5	48.7	52.5
D_{15}	18.9	22.0	25.8	28.2	30.0	33.6
			80 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	58.1	64.7	70.9	74.8	77.4	81.1
D_{10}	33.6	38.8	44.3	47.5	49.7	53.6
D_{15}	19.2	22.9	26.8	29.3	31.1	34.9
			100 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	59.1	65.8	72.2	76.1	78.8	82.5
D_{10}	34.7	40.0	45.8	49.1	51.4	55.3
D_{15}	20.1	24.0	28.1	30.7	32.6	36.5
			H.V.L. 9.0 mm. Copper			
			50 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	60.8	65.9	70.9	73.6	75.5	78.2
D_{10}	35.9	40.0	44.7	46.8	48.0	50.8
D_{15}	20.8	23.5	26.6	28.4	29.6	32.0
			60 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	62.1	67.3	72.4	75.2	77.1	79.9
D_{10}	37.4	41.7	46.6	48.8	50.0	53.0
D_{15}	22.0	24.9	28.1	30.1	31.3	33.9
			70 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	63.2	68.4	73.6	76.4	78.4	81.0
D_{10}	38.6	43.0	48.1	50.3	51.6	54.6
D_{15}	23.5	26.4	29.6	31.6	32.9	35.5
			80 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	64.0	69.4	74.6	77.4	79.4	82.3
D_{10}	39.4	43.9	49.1	51.4	52.7	55.8
D_{15}	24.0	27.1	30.7	32.8	34.2	36.9
			100 cm. distance			
D_0	100.0	100.0	100.0	100.0	100.0	100.0%
D_5	65.1	70.5	75.9	78.8	80.8	83.7
D_{10}	40.7	45.4	50.6	53.0	54.4	57.6
D_{15}	25.1	28.5	32.2	34.4	35.8	38.7

For focal distances from 50 to 100 cm. we found that the values for D_5, D_{10}, and D_{15} lie between the figures published by these two authors, and are independent of the quality and field size for fields 25 sq. cm. or larger. Curves showing the variation of D_5, D_{10}, and D_{15} with distance are given in Figure 7. In applying these distance ratio curves it is important to maintain the factors of quality and area constant.

Continuing with the same example used to illustrate the use of the quality ratio and the area ratio curves, let us suppose that the radiologist, having now obtained a depth curve for a quality of 2.5 mm. copper H.V.L. and a field size of 80 sq. cm.,

chooses to use a greater distance, perhaps 100 cm. instead of 70 cm. From the distance ratio curves we determine the ratio of 70 cm. to 100 cm. distance for D_5, D_{10}, and D_{15}. Then the conditions of 80 sq. cm. area, 2.5 mm. Cu H.V.L., and 70 cm. distance are to the conditions 80 sq. cm., 2.5 mm. H.V.L., and 100 cm. distance as 1.039:1.07 for D_5; 1.075:1.134 for D_{10}; 1.113:1.21 for D_{15}.

Relative depth doses for any combination of treatment factors may be obtained by utilizing the three families of ratio curves presented, provided depth dose values are known for one set of conditions of area, quality, and distance. Utilizing the three families of ratio curves in conjunction with the average measured values, obtained by means of a thimble-type ionization chamber and a presdwood (masonite, phantom 30 × 40 × 28 cm. thick, we have developed the depth dose table reproduced here as Table I. The D_{10} values for areas of 50, 100, and 400 sq. cm. areas and distances of 50, 70, and 80 cm. are shown in Figure 8. The continuous lines represent our average values, the actual average points being omitted to avoid confusion with the points representing the published values of other authors. Similar curves were drawn for D_5 and D_{15} values but, to conserve space, are omitted from this paper. Decidedly fewer data have been published for these depths, and among those published the variation is far greater than for the D_{10} values.

SUMMARY

Ratio curves for quality, area, and distance, based on numerous measurements made at the State Institute for the Study of Malignant Diseases (New York) during the past several years, have been presented, providing a means of establishing depth-intensity curves for any set of conditions used in x-ray therapy, from 200 to 1,000 kv. A comparison is made with the published data of other authors. A depth-dose table is presented covering a range in quality from 0.9 to 9.0 mm. copper H.V.L., areas from 25 to 400 sq. cm., and distances from 50 to 100 cm.

State Institute for
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Buffalo, N. Y.

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Quality, Area, and Distance Relationship for D_5, D_{10}, and D_{15}. II

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Buffalo N. Y.

IN THE PRECEDING article the authors have presented curves and tables showing the relationship between depth intensities and the three other factors, quality of radiation, treatment area, and focal skin distance, and have demonstrated a method of transposing a known depth dose for one set of conditions to any other desired set of conditions providing both are within the following range: 0.9 to 9.0 mm. copper H.V.L., 25 to 400 sq. cm. treatment area, 50 to 100 cm. focal skin distance. It is intended here to consider depth doses associated with the lower voltages, including the qualities from 2 to 12 mm. aluminum H.V.L., areas from 10 to 200 sq. cm., and distances from 20 to 60 cm. Thus the quality range considered here is an extension of that considered in the preceding paper, where the lower limit of quality was 0.9 mm. copper H.V.L., which, expressed in terms of aluminum, is 12.1 mm. aluminum H.V.L.

The data necessary to make this extension were obtained during the last several

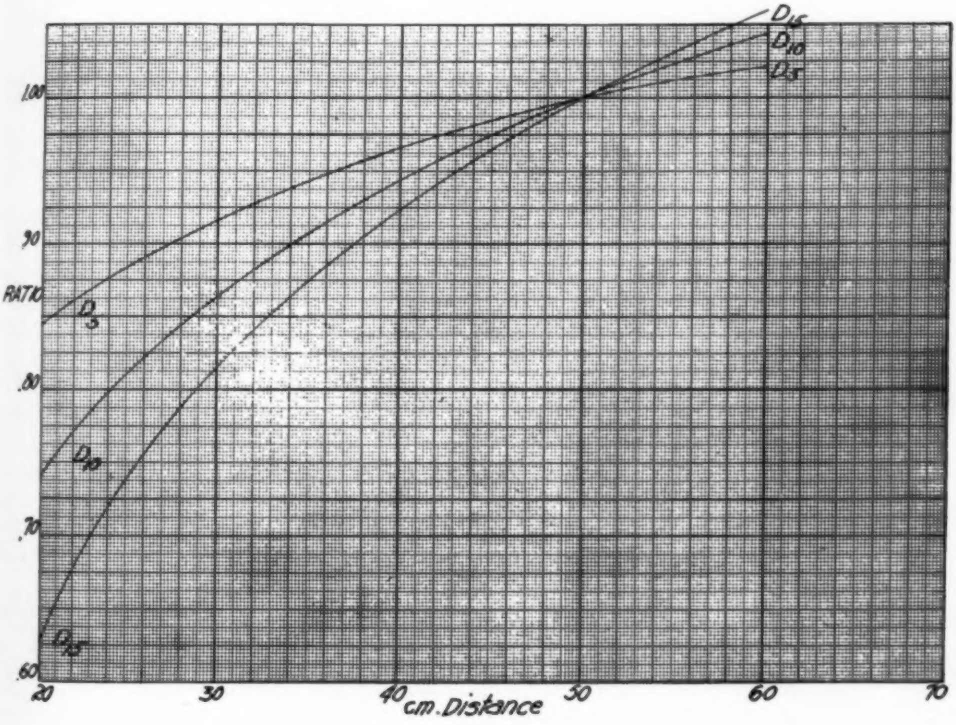

Fig. 1. Distance ratio curves for D_5, D_{10}, and D_{15}.

[1] From the State Institute for the Study of Malignant Diseases, Buffalo, N. Y. Burton T. Simpson, M.D., Director. Paper accepted for publication in December 1942.

TABLE I: AREA AND QUALITY RATIOS

H.V.L. mm.	10 sq. cm.	25 sq. cm.	50 sq. cm.	80 sq. cm.	100 sq. cm.	200 sq. cm.
			D_5			
2 Al	0.51	0.582	0.643	0.689	0.71	0.782
4 Al	0.612	0.701	0.777	0.831	0.86	0.95
6 Al	0.672	0.775	0.866	0.934	0.966	1.06
8 Al	0.708	0.822	0.926	1.004	1.04	1.144
10 Al	0.734	0.858	0.970	1.055	1.095	1.203
12 Al	0.748	0.881	1.00	1.093	1.136	1.255
			D_{10}			
2 Al	0.28	0.346	0.405	0.453	0.477	0.561
4 Al	0.413	0.521	0.617	0.698	0.735	0.85
6 Al	0.496	0.629	0.758	0.850	0.897	1.05
8 Al	0.546	0.705	0.858	0.970	1.023	1.195
10 Al	0.58	0.762	0.935	1.065	1.126	1.321
12 Al	0.603	0.809	1.00	1.14	1.21	1.424
			D_{15}			
2 Al	0.167	0.215	0.262	0.299	0.317	0.382
4 Al	0.30	0.399	0.495	0.571	0.611	0.731
6 Al	0.376	0.510	0.648	0.758	0.812	0.990
8 Al	0.439	0.608	0.781	0.919	0.990	1.203
10 Al	0.48	0.683	0.898	1.051	1.129	1.382
12 Al	0.512	0.756	1.00	1.184	1.269	1.545

years by measurements with a thimble-type ionization chamber in a "presdwood" phantom described in the previous paper. These measured values, assembled with the published values of numerous other authors, are the source from which the accompanying curves and charts, expressing the relationship of quality, area, and distance for D_5, D_{10}, and D_{15} were derived. A plot of these three points in relation to D_0, or 100 per cent on the surface, permits a smooth curve to be drawn indicating the depth intensity along the central ray and making it possible to read any other depth value (D_x) desired from the curve.

DISTANCE

The distance relationship for D_5, D_{10}, and D_{15} was calculated from the assembled data, making it possible to extend the distance curves presented in the previous paper to 20 cm. distance. See Fig. 1.

While in a broad sense this distance relationship is independent of quality and area, and it is possible to determine the intensity at 30 cm. distance from a known value at 60 cm. distance for one quality and one field size, it is not possible to convert directly from 200 sq. cm. and 4 mm. Al H.V.L. at 30 cm. to 10 sq. cm. and 8 mm. Al H.V.L. at 60 cm. distance. To accomplish this transition, that is, to change from one quality, area, and distance to another combination of the three factors, one additional step is necessary. See under heading Quality and Area.

To illustrate the use of the distance curves, the following example is offered: Suppose it is desired to determine the depth values at 30 cm. when the depth intensities at 60 cm. are known. In order to make this transition, it is necessary to keep the quality and treatment area constant. Assuming that the known depth dose for a beam of x-rays, 0.9 mm. copper H.V.L. at a 60 cm. distance for a 25 sq. cm. area, is 50 per cent for D_5, 23.5 per cent for D_{10}, 10.7 per cent for D_{15}, the depth values for the same area and quality at a distance of 30 cm. may be obtained as follows.

From the distance ratio curves, the ratio of $\dfrac{60 \text{ cm. distance}}{30 \text{ cm. distance}}$

$$\text{for } D_5 \text{ is } \frac{1.023}{0.916}$$

$$\text{for } D_{10} \text{ is } \frac{1.045}{0.864}$$

$$\text{for } D_{15} \text{ is } \frac{1.06}{0.814}$$

Then, by a simple proportion, the value may be obtained for

$$D_5 \text{ by } \frac{1.023}{0.916} = \frac{50}{x}$$

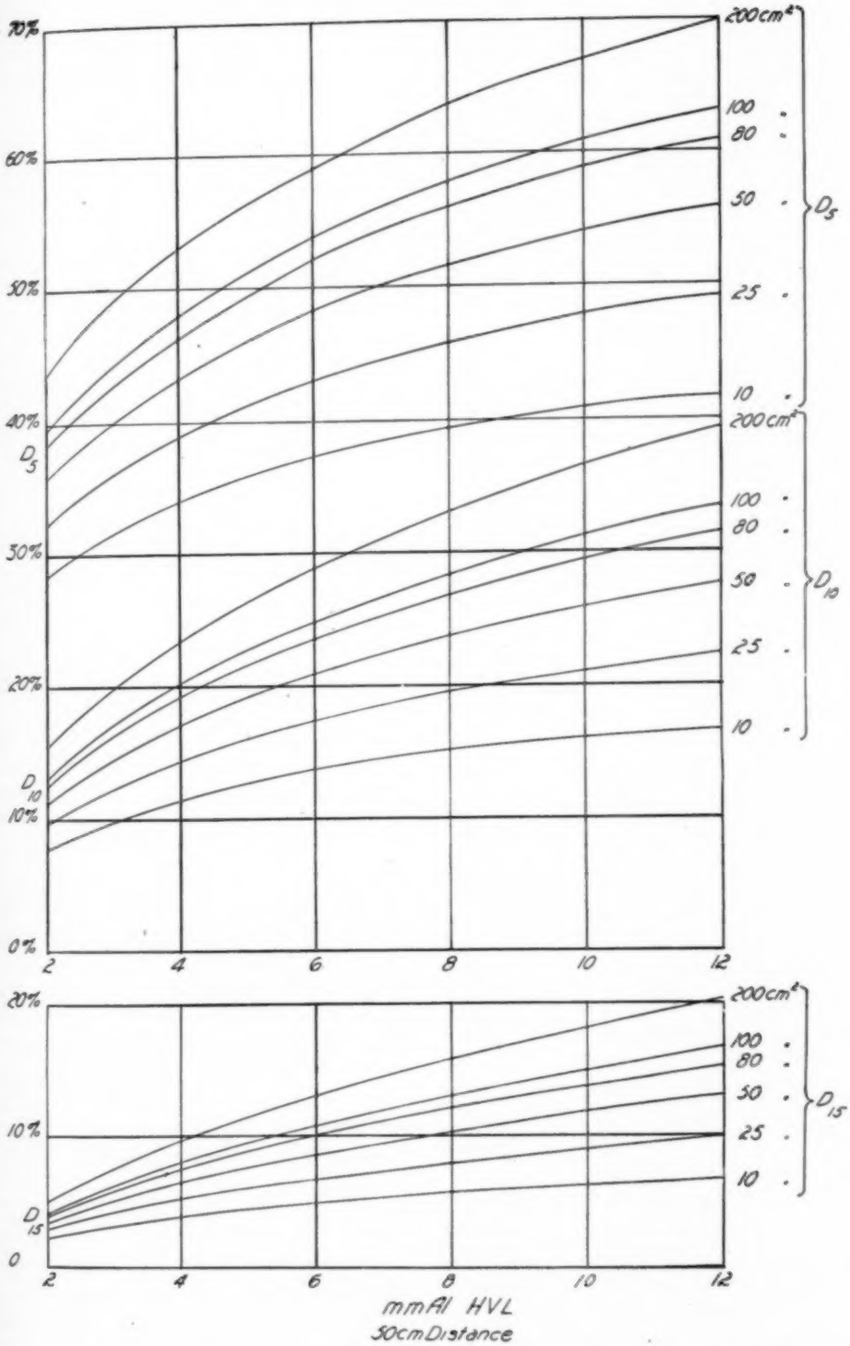

Fig. 2. Depth intensity curves for D_5, D_{10}, and D_{15} at 50 cm. distance, for field sizes 10 to 200 sq. cm.

x = 44.8 per cent D_5 value for 30 cm. distance.

$$D_{10} \text{ by } \frac{1.045}{0.863} = \frac{23.5}{x}$$

x = 19.4 per cent D_{10} value for 30 cm.

$$D_{15} \text{ by } \frac{1.06}{0.814} = \frac{10.7}{x}$$

x = 8.2 per cent D_{15} value for 30 cm.

A plot of these three points together with the surface intensity as 100 per cent permits a smooth depth curve to be drawn.

QUALITY AND AREA

Whereas in the previous paper we presented separate families of curves expressing the relationship in the form of ratios between depth dose and quality on the one hand and between depth dose and area on the other hand, in this paper we have consolidated both into one chart (Table I). This table expresses the ratio between depth values of any one of the three depth levels for the areas and qualities shown, when the value for 50 sq. cm. and 12 mm. Al H.V.L. is considered as unity.

Let us suppose that a roentgenologist is working at a distance of 50 cm., a quality of 8 mm. Al, and a 100 sq. cm. field and knows the D_5 value is 57.9 per cent; D_{10} value is 28.4 per cent; D_{15} value is 13.1 per cent, but he wishes to obtain the depth values for an area of 10 sq. cm. and a quality of 4 mm. Al H.V.L., also at 50 cm. distance.

From Table I the ratio values for 8 Al and 100 sq. cm. area are:

$$D_5 = 1.04$$
$$D_{10} = 1.023$$
$$D_{15} = 0.99$$

while the ratio values for 10 sq. cm. area and 4 mm. Al are:

$$D_5 = 0.612$$
$$D_{10} = 0.413$$
$$D_{15} = 0.30$$

Then the problem may be stated as follows:

$$D_5 \frac{1.04}{0.612} = \frac{57.9}{x}$$

x = 34.1 per cent D_5 value for 10 sq. cm. and 4 mm. Al.

$$D_{10} \frac{1.023}{0.413} = \frac{28.4}{x}$$

x = 11.46 per cent D_{10} value for 10 sq. cm. 4 mm. Al H.V.L.

$$D_{15} \frac{0.99}{0.3} = \frac{13.1}{x}$$

x = 3.97 per cent D_{15} value for 10 sq. cm. 4 mm. Al H.V.L.

These three points, when plotted together with the surface intensity of 100 per cent, will form a smooth depth curve. For qualities and areas intermediate to those shown in the table, an interpolation will give a good approximate value.

The application of the distance curves together with the quality-area ratio tables makes it possible to determine the depth intensity for any desired combination of quality, area, and distance, from known depth values at another combination of quality, area, and distance within the limits shown. By using Figure 1 and Table I in conjunction with average measured values, a complete set of depth intensity curves for D_5, D_{10}, and D_{15} at 50 cm. target skin distance for field sizes 10 to 200 sq. cm. area and qualities from 2 to 12 mm. Al H.V.L. were obtained as shown in Figure 2.

When it is desirable to refer depth intensities to measured values in air (no back-scatter) it is necessary to utilize tables of scattering values for various field sizes and qualities. This information for a limited number of field sizes and qualities is contained in Technical Bulletin No. 1 of the Radiological Society of North America Standardization Committee (Quimby, E. H., and Laurence, G. C.: Radiology 35: 138–159, August 1940). It is intended to publish back-scatter values at some future time for the various qualities and field sizes mentioned in this paper.

SUMMARY

Curves and tables are given, permitting the calculation of depth doses within the range of 2 to 12 mm. Al H.V.L., 20 to 200 sq. cm. area, and 20 to 60 cm. distance, when a change is made in either quality, treatment area, or distance.

Use of Small X-Ray Films in Tuberculosis Control[1]

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ALTHOUGH X-RAY examination of the chest is unanimously held to be the most accurate and effective method for the diagnosis of pulmonary tuberculosis, it is only recently that the procedure has come to be utilized on a wide scale. Tuberculosis is a disease which affects a large segment of the population, and therefore *mass* case-finding programs are necessary for its control. Standard x-ray procedure, however, involving use of 14 × 17-in. film, is too costly to permit the application of this method on a large scale. A cheaper and more widely applicable technic has long been needed. Such a technic now has been provided through the use of small (35-mm.) films. As a result of increasing use of this method, x-ray examination has at last assumed the role it deserves as a weapon in the fight against tuberculosis.

Considerable impetus has been given recently to mass x-ray surveys by the case-finding programs of the Army, Navy, and Coast Guard. Before being inducted into the Army or Navy every man and woman recruit is given a routine small-film chest examination. Similar tests will soon be given to all Coast Guard recruits. The significance of this case-finding activity becomes apparent when we realize that some 13 million persons—approximately one-tenth of the population—will be examined. Nothing on a comparable scale has ever been attempted. It will be recalled that during the last World War, chest x-ray examination was not a part of the induction procedure.

Furthermore, the United States Public Health Service recognizes that tuberculosis among the civilian population constitutes a special threat to the Nation during war time. It has therefore established a tuberculosis control program in which x-ray examination of large numbers of war workers and their families will play an important part.

The intimate relationship between war and communicable disease is manifested with particular emphasis in the case of tuberculosis. The last world conflict sent tuberculosis rates soaring in the nations of Europe and brought about a slight rise even in America. Today, alarming increases are again being observed throughout Europe. No one can predict how extensive the damage will be. Although there has been no apparent increase in the amount of tuberculosis in this country, the objective circumstances favoring such an increase are much in evidence. These circumstances are:

(1) Large-scale concentrations of industrial workers and their families in newly developed communities which do not have proper housing facilities, adequate sanitation, or provisions for even minimum medical care.

(2) Employment by industry of hundreds of thousands of women and other workers who are not accustomed to heavy labor. Among these workers there are many with arrested tuberculosis who will break down under the strain of the job. Many cases of tuberculosis will become reactivated and thus endanger both the affected worker and those with whom he has contact.

(3) Fatigue and insufficient rest resulting from the increased working hours and pace required to keep the war machine going. Persons who have never had the disease may be rendered more vulnerable to attack by the tubercle bacillus.

These unfavorable circumstances provide the soil in which various types of illness and disability take root and grow. As far

[1] Presented before the Radiological Society of North America, at the Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30–Dec. 4, 1942.

as tuberculosis is concerned, it strikes down the very ones who are most valuable as fighters and workers—men and women between the ages of twenty and fifty. When protected from the disease, these persons are the human assets upon which the presumption of victory is based. When attacked by tuberculosis—and from 1 to 2 per cent of our manpower is so attacked—they become liabilities, performing their jobs inefficiently and spreading sickness to others. Moreover, they require costly services and personnel that otherwise might be devoted to prosecution of the war.

In addition to the maintenance of standards of health and medical care for the general population, there are certain specific measures which can be undertaken to prevent the expected war-time rise in tuberculosis rates in the United States. These measures are defined in the objectives of the Office of Tuberculosis Control recently established by the U. S. Public Health Service. The objectives are:

(1) Chest x-ray examination of workers in war industries in every state in the Union, as part of the nation-wide industrial hygiene program for the conservation of manpower.

(2) Extension of this case-finding service to families of war workers found to be tuberculous, especially those in minority and under-privileged groups. This part of the program is conducted as an integral part of the local health department's activity.

(3) Extension of the case-finding program of the armed forces to include all recruits of the Coast Guard. For some months, the U. S. Public Health Service has been examining all men at one of the Coast Guard induction stations. This service will soon be made part of the induction routine at the other stations.

(4) Development of a workable system of reporting tuberculosis discovered in all rejected recruits to state health departments and other official agencies responsible for tuberculosis control. Thorough and prompt reporting is necessary in order that cases may be given immediate clinical examination, treatment, and care within the limit of available local resources.

(5) Encouragement and assistance in the establishment of x-ray examination procedures in the admitting rooms of general hospitals and in state hospitals for the mentally ill. Patients in the latter type of hospital constitute an especially important reservoir of infection. Institution of small-film screening procedures in hospitals would be a simple and inexpensive way to bring a large amount of undetected pulmonary tuberculosis under control.

(6) At the request of state and municipal agencies, rapid inventory of existing control programs, and assistance in the reorganization of such programs in accordance with war-time needs. By such means the efforts of both official and voluntary agencies can be co-ordinated, economy can be achieved, and duplication of effort avoided.

Of major interest to roentgenologists are the small-film surveys conducted in war industries by the Office of Tuberculosis Control in co-operation with the Division of Industrial Hygiene of the National Institute of Health.

Each survey unit consists of a medical officer, an x-ray technician, a clerk, and complete equipment for exposing and processing 35-mm. films. This includes a portable 200-ma. generator, a rotating anode tube, and a stationary grid. The personnel and equipment are loaned to state health departments upon request for use during a limited period in war industries where such equipment is not available. Since the purpose of these surveys is primarily to demonstrate the need for a case-finding program, no charge is made for the service. The industry, however, is asked to provide necessary clerical assistance. Industrial establishments are then encouraged to procure their own equipment and personnel for carrying on the work permanently. An important advantage of these units is that they provide training for personnel who can be assigned to State health departments to assist in the establishment of industrial hygiene and tuberculosis control programs.

The medical man in charge of each of the eight survey units now in the field is a full-time commissioned officer of the Public Health Service who has had some specialized training in either roentgenology or tuberculosis, or both, and who has undergone a special course in small-film interpretation under the supervision of recognized roentgenologists and tuberculosis specialists. Not until the medical officer has reduced his "over-reading" error to 5 per cent and his "under-reading" error to 3 per cent of minimal lesions in a test series of 1,000 films is he sent into the field in charge of a unit.

Besides the eight 35-mm. units now in operation, the Public Health Service has two 4 × 5-in. units for use in industrial surveys.

Thirty-five-millimeter photofluorograms are used by the Public Health Service in its industrial and Coast Guard surveys because it is believed that they provide a satisfactory method of quickly and economically finding the great majority of significant cases of pulmonary tuberculosis among large groups of examinees. Experience with this type of equipment in Minnesota and Washington, D. C. has demonstrated that less than 10 per cent of cases with minimal lesions are missed. Advanced lesions are detected as accurately as with films of the regular size.

Speaking from an epidemiological point of view and assuming adequate treatment facilities, the control of tuberculosis would be simple if all except 10 per cent of minimal cases could be discovered. As a matter of fact, about one-third of the so-called minimal cases detected by x-ray examination are found, when studied clinically, to be inactive. An additional one-third are dubiously tuberculous on the basis of clinical findings and warrant only an indeterminate diagnosis. Thus, the proportion of *significant* minimal lesions not discovered by the 35-mm. technic is closer to 3 per cent than 10 per cent. From a public health standpoint, this small proportion is relatively unimportant. Considering the health of the group as a whole, it is of greater value to examine 100,000 persons with small films and miss a few minimal cases than it is to examine one-tenth that number with the more expensive 14 × 17-in. celluloid films and leave 90,000 persons without benefit of any x-ray examination whatever.

Sound public health practice demands that the method used be one that benefits the group rather than merely the individual. Until funds are available to permit use of a practically unlimited quantity of high-grade 14 × 17-in. celluloid films, the small films will have to serve. Money, however, is not the only thing lacking; in mass survey work, the time of the skilled personnel is also important. Using the 35-mm. film, it is possible for one survey team to expose, process, and interpret as many as 500 films a day. This is fully twice the number of large films that they could handle in a day.

It should be made clear that the purpose of reading the small films is not to diagnose pulmonary tuberculosis, but rather to screen out for further study all cases with parenchymal lesions. The developed films are classified into three groups: abnormal, suspect, and negative. Later, 14 × 17-in. films are taken of all persons whose small films were classified as either "abnormal" or "suspect," and the large films are then interpreted by experts in roentgenology and tuberculosis.

The "suspect" group is included in the retakes in order to increase accuracy and reduce fatigue on the part of the reader. It is wiser and cheaper to take a few extra 14 × 17-in. films (here is where the "over-reading" comes in) than it is to wear out the eyes and the nerves of the interpreter. By putting aside all doubtful cases for future confirmation, the physician can easily read from 400 to 600 films during a four-hour session. At least, this has been the experience of the eight medical officers who have interpreted the first 100,000 films taken in the Public Health Service surveys.

Some interesting results have been obtained in the surveys conducted so far. Among a group of 1,200 men and women

workers in an ordnance plant, there were found 4 cases of previously unknown minimal tuberculosis; 7 cases of moderately advanced disease, 2 of which had cavities; 2 far-advanced cases. The average incidence of reinfection tuberculosis found among industrial workers has been slightly more than 1 per cent. This indicates that in the fight to conserve manpower for war production, tuberculosis is a silent enemy worthy of consideration. Unless steps are taken to retard its spread, the 1 per cent of infected workers may pass the disease on to their fellow employes, as well as to members of their own families.

Another survey of 5,000 persons belonging to a minority group in one of the principal defense areas in the South disclosed 207 persons, or 4.1 per cent, with significant pulmonary tuberculosis.

Other conditions besides tuberculosis are frequently discovered by means of the small films used in these surveys. In the southern survey just mentioned, a massive symptomless tumor of the mediastinum was found in one of the women examined. She was referred to a specialist for differential diagnosis, with the result that a chest surgeon removed a dermoid cyst about the size of a baby's head. Recovery was uneventful. This was only one of several intrathoracic tumors discovered in an operable stage by such surveys.

The ninety-fifth Coast Guard recruit who was examined by the P-F unit in Baltimore, Md., had been in training for some weeks and was ready to board a vessel for prolonged duty at sea. The picture of his chest, however, revealed moderately advanced tuberculosis with definite cavitation. As a result, he was sent to a marine hospital for care and treatment. Had he gone to sea, the possibility of infecting some of his shipmates in the crowded quarters of the vessel would have been great.

This is but one illustration of the wisdom of our military authorities in adopting chest x-ray examinations for all men going into the service. In this connection, also, the report brought back by a Public Health Service officer who was stationed in Germany prior to the declaration of war is illuminating. This officer stated that a high tuberculosis rate is being noted among British soldiers in German prison camps. These soldiers were not given chest x-ray examinations before induction into the British army. German soldiers, on the other hand, were x-rayed prior to induction, and it is known that few of those now held in British prison camps are breaking down with tuberculosis. While differences in the food allowances granted to prisoners in the two countries may account to some extent for the higher rate of breakdown among British prisoners, the fact that among the latter there are many with inactive or undiagnosed tuberculosis is undoubtedly an important factor.

Recently, the Public Health Service received a hurry call to send one of its P-F units to Mexico City to examine migratory Mexican workers who were to be brought into the United States to help gather the vital fruit crop in California. Accordingly, the unit operating in San Antonio, Texas, quickly disassembled its equipment, loaded everything into a station wagon, and set out for Mexico City. Twenty-four hours after its arrival it was in action, examining the workers and eliminating those with tuberculosis. In this way these persons were prevented from bringing the disease into this country and spreading it to other workers.

If cases of tuberculosis can be discovered early, isolated and treated, and given proper after-care and rehabilitation, the disease can be controlled even in war time. This is so well recognized that it is axiomatic. But the examinations through which the disease is discovered must be conducted on a large scale and in a reasonably short period of time. The small-film technic is the only one available at the present time which fulfills these requirements. As such it becomes a tool which we cannot afford to neglect.

SUMMARY

Chest x-ray examinations of large groups of people is an essential procedure in an

adequate tuberculosis control program, especially in time of war. Every recognized method of x-ray examination should be used, the choice of method depending upon the funds, equipment, and personnel available. Especially important at the present time is the availability of medical personnel trained in the important task of interpreting films. Tuberculin testing of adult workers is usually not practicable because of the high proportion of positive reactors and because it takes the worker away from his job for too long a time. Tuberculin testing is, however, of real value in differential diagnosis of minimal lesions discovered by x-ray examination, when it is used in conjunction with culture examination of stomach washings for virulent organisms.

Thirty-five-millimeter photofluorograms are especially adapted for mass case-finding work because of their low cost. With limited training in film interpretation, medical officers can screen out chest abnormalities and cases of suspected tuberculosis. Diagnosis can then be confirmed by means of large films interpreted by experts. Epidemiologically this procedure is satisfactory and it results in conservation of specialized personnel.

The net effect of the increasing use of small films, as far as the roentgenologist's practice is concerned, is that it will result in the use of more large films than ever before. The roentgenologist should welcome the opportunity to interpret his share of these films. As chest x-ray examination becomes a routine procedure in private and public industrial hygiene programs, additional opportunity will arise for the roentgenologist to serve as consultant to industrial concerns. State health departments with small-film units could advantageously employ young roentgenologists in training at hospitals and teaching institutions as consultants for preliminary screening when full-time medical officers are not available.

A word of caution is necessary with regard to the interpretation of small films by roentgenologists. It is unfair for any professional man to pass judgment on the comparative value of a new technic until he has had considerable experience with it. This is especially true of small-film interpretation. Several hundred films must be carefully read and studied before the interpreter learns to accommodate himself to the new anatomical and pathological relationships involved.

It should also be borne in mind that mass x-ray surveys are concerned with the well-being of the group as a whole. With this group orientation, the interest of the individual, as such, will sometimes be overlooked. Nevertheless, all individuals are benefited by improvements in the general level of health and in their environment.

The redoubled effort necessary to keep tuberculosis in check during this national crisis requires the fullest co-operation by all health agencies and groups. Official and voluntary agencies, as well as professional societies, have a contribution to make. The Radiological Society is composed of persons whose special training and skill are invaluable in the effort to conserve and achieve the fullest use of the nation's manpower. We therefore earnestly solicit its co-operation in utilizing what we believe to be an essential tool in tuberculosis control—a tool which will provide chest x-ray examinations for the largest number of people in the shortest possible time.

U. S. Public Health Service
Washington, D. C.

EDITORIAL

Howard P. Doub, M.D., Editor

John D. Camp, M.D., Associate Editor

War-Time Radiology

Presidential Address[1]

The Radiological Society of North America has always expected its President to deliver an address at its annual session. In attempting to fulfill this expectancy, I find myself in an atmosphere in which the usual or customary form of address would seem merely casual or, at least, unfitting. We are all supremely mindful that since the last Presidential Address was delivered, at our meeting on the Pacific Coast, we have been precipitated into a war of the greatest magnitude ever known. During this period, the medical profession, true to its finest tradition, has volunteered its services to our Government, and vast numbers of its members are now serving in the armed forces of our country in nearly every part of the world. Many more are eagerly awaiting their call and they, too, will most willingly make any sacrifice in order to aid in bringing this war to a successful issue. To help accomplish this, all of the resourcefulness of the medical profession is needed in one form or another. The same spirit of cheerful co-operation must stimulate those who remain at home to accept the added drudgery and to aid in the care and consideration of civilian needs in the true spirit of defense. It behooves them, and they are accepting the responsibility, to adjust themselves to a different order of medical service, a departure from the deep-rooted customs and habits which heretofore encompassed their very existence and practice.

The part which Radiology is playing in this war and the sacrifices which are being made by the individual radiologist are well known to all of you. It is, however, especially gratifying to know that our war efforts and our peace-time accomplishments have come to the attention of our national governmental authorities. This is clearly evidenced this evening by the presence here of Army, Navy, and Public Health officials who, in response to our invitation, were assigned by the Offices of the Surgeons General of the Army, Navy and Public Health Service to represent them on this occasion of the assembly of our Society. By this recognition our entire membership is honored and we most gratefully pledge tonight our continued loyalty to our glorious Government. To it we offer full support, co-operation, and untiring efforts toward the ultimate defeat of our enemies, and the resulting establishment of the peace, tranquility, liberty, and happiness for which torn, shattered, suffering humanity so intensely yearns.

During my war-time term of office, I have appreciated the necessity for a still closer and a more intensely cordial relationship with our confreres in Radiology in all of America. With the approval of your officers, therefore, I sent invitations to our brothers in Radiology in the various countries of South and Central America to attend this meeting of the Radiological Society of North America. The many cordial and friendly responses that were received have, indeed, overwhelmed me.

[1] Delivered before the Radiological Society of North America at the Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30–Dec. 4, 1942.

The sincerity and willingness of our Latin-American colleagues to co-operate with us not only in the science of Radiology, but in its full war-time application, is a most tangible and satisfying index of their earnest desire to establish a lasting and purposeful scientific understanding among the radiologists of the entire hemisphere. In this connection, it has been suggested that the radiological literature appearing in our journal be summarized in Spanish and we know that our good neighbors will be willing to render us a like service. Our exchange of journals will then lead to a mutual appreciation of radiological progress and achievements in Continental America. In time, as we now fully realize, all educated English-speaking persons will know Spanish and those speaking Spanish will know English. Space is becoming rapidly obliterated and neighbors must be capable of conversing with one another.

We, engaged in the specialty of Radiology, both of the North and of the South, fully accept a personal responsibility in continuing the march of radiological progress during this war. Our efforts are directed toward improving and devising better radiological equipment along with rapid and accurate diagnosis as the exigencies of war may require. We must ever be war-minded, giving to our utmost physical endurance all that we possess in order that our armed forces may have the best radiological facilities in the world.

Some of us may be tempted to forget love of country for selfish gains and personal benefits. Some may even soothe their consciences in the belief that whatever is profitable is right. Such thoughts only smack of Hitlerism: we cannot countenance motives of personal gain, but must think more and more of our common cause—all for one, and one for all humanity. The words of Shakespeare in *Henry VI* must be ever present in our minds, "Now join your hands, and with your hands your hearts, that no dissension hinder government."

To all of our confreres in every branch of military service—everywhere on our mundane sphere—in battle for the preservation of humanity and our ideals of civilization, we proudly express our glory in their achievements, our admiration of their great sacrifices!

In every branch of our military organization where Radiology can lend its helpful hand, we know our representatives are carrying on their mission of service and work of mercy. We know that our fellow specialists in uniform are fulfilling, to the utmost degree, every expectancy of service that lies within the scope of Radiology to furnish. Our hearts swell with pride in their patriotic accomplishments, while those of us not so blessed feel a moistening of our eyes, a pathos, a sincere regret that various causes may have hindered our participation in such glory. We are confronted, none the less, with important services and duties. For those in the "plain clothes brigade" the work at home is heavy and demanding: the care of the unfortunates in our hospitals; the training in medical schools and hospitals; the meeting of civilian needs. These duties are both exacting and intense.

The absence of our younger and more resilient staff members, who are now fulfilling the necessities of military service, has made our burden a heavy one. We carry it cheerfully as best we are able, gladly fulfilling our part in the cause of our glorious country! Cheerfully for the sake of humanity! For the sake of the future return and restoration of those of our brothers who have been called away. For whatever assistance we may give in the reconstruction and rehabilitation that needs must follow our final victory we are indeed grateful. Let those who, for whatever reason or infirmity, stand by in the more humble capacity of "Home Front" service, seek solace and comfort in the additional fact that many are thereby set free for the needs of combat.

Let us all, unified in a common cause, hope and pray that from the darkness of Africa there will arise the flashing light rays of power that will bring peace once

more to all mankind. 'Tis true that "those also serve who only stand and wait," but always must there be a unity of all, for in unity alone is there strength for action and, what is more, for the victorious achievement of an honorable purpose, for which we beg the Great Almighty's aid. LEON J. MENVILLE, M.D.

Roentgenology and This World-Wide War[1]

ALFRED A. de LORIMIER

Lieut. Colonel, Medical Corps, U. S. A., Commandant, The Army School of Roentgenology, Memphis, Tenn.

Mr. President, Distinguished Guests, Visitors, and Fellow Members of the Radiological Society of North America:

The honor of speaking before you, this evening, is fully appreciated. Your interests in the activities of the Medical Department of our Army are held in high respect by the Surgeon General. He has directed me to convey to you his greetings.

Today, every American has developed a conception of his responsibilities and his particular part in consummating the great task with which we are confronted. Radiologists and their manufacturing confreres have always been at the top in patriotic enthusiasm. The interests and activities of our radiological organizations—the American College of Radiology, American Roentgen Ray Society, and our Radiological Society of North America—have demonstrated the truth of this statement. The Surgeon General is fully aware of these co-operative interests. They have been of great benefit in selective assignments, the development of co-ordinating teams and, in general, in expediting radiological arrangements for our armed forces.

Now, we can look ahead to the horizon of success; success, at least, in so far as the immediate objective is concerned. Within an astoundingly short period of time (approximately half that required for mobilization of our forces in the last World War), we are actually diving into this conflict. Successful combat strategy has already been developed, and we of the Medical Department are keeping pace with the combatant forces—even with their rapid progress. We are equipped to handle mass responsibilities on fast moving fronts.

In this era of world-wide destruction, our troops are required to move into practically every sector of the globe. They must face enemies ahead, enemies on either flank and behind, as well as enemies in the air. Moreover, the advance of civilization has brought with it an advance of *uncivilization:* developments which may be characterized as improvements in the efficiency of destruction. Because of these factors, it can be expected that there will be a higher incidence of immediate death among our war casualties than in the last World War. No doubt, too, there will be a greater degree of crippling and disfigurement of our wounded.

For the Medical Department, this means the requirement of rapid evacuation of the wounded to greater distances from the line of combat than were formerly necessary. It means that for any definitive surgical handling (and radiological assistance), we must function not a mile or a few miles back but tens and even hundreds of miles to the rear. We must adjust ourselves to shelters not only out of range of land trajectories but shelters concealed from aerial view. There, possibly in uncomfortable situations, without the assistance of elaborate auxiliary devices, we must exercise our roentgenoscopic discernment

[1] An address delivered before the Radiological Society of North America, at the Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30–Dec. 4, 1942.

in a gamut of conditions which ordinarily we would study on the roentgenogram with various projections. We must recognize roentgenoscopically even the most difficultly discernible types of fracture—such as those of the maxillo-facial region and the skull. We must be co-operative to the highest degree with the surgeon in his handling of such cases. We must diplomatically advise him not only as to diagnoses but also as to limitations of x-ray exposures. We must not only be equipped to localize shrapnel and bony fragments by the roentgenoscopic technic—which is practical in most parts of the body; we must be able, also, to proceed with reorienting relations at the operating table, thereby assisting the surgical approach with respect to any selected site of incision. Moreover, we must be efficient in the localization of intraocular foreign bodies.

True enough, this war has not yet been won, but relying upon determination and perseverance, with the developments thus far accomplished, we can foresee inevitable success. The time is almost at hand for us to think of additional responsibilities; responsibilities other than those concerned with our functioning in the theater of operations.

Unusual infections may be expected to occur, sporadically or even on a large scale. Our troops are going to all parts of the world. It would seem to be a sound epidemiologic conclusion that, lacking immunity to certain organisms, these men may develop, in severe form, diseases which have existed locally to a degree of no appreciable importance, and that virulence of the organisms concerned will thereby become fortified.

During the last great conflict, we experienced an epidemic of what was generally designated as influenza. Today, we are considering virus pneumonias or, as we call them in the Army, "atypical pneumonias." There is some reason to believe that many of these infections may represent the flu of twenty-five years ago. Moreover, there is good basis for the belief that these atypical pneumonias include a variety of etiological types. Already, our leading roentgenologists are attempting to distinguish a non-specific virus group from a true psittacosis and to separate these from pneumonic processes produced by toxoplasmosis or the rickettsia of Q-fever. Then, too, we may expect to encounter such conditions as plague pneumonias, those associated with lymphogranuloma venereum and other virus diseases, as well as histoplasmosis and true fungus lesions of the lungs. It is important that we roentgenologists recognize the finer points which may lead to distinction of these various types of pneumonic lesions, for treatment of one is now known to be quite different from that required for another.

Our Army is the first to have developed routine methods for accomplishing etiologic diagnoses, providing for truly identifying roentgenologic evidence. We must be alert to the great strides which have been made in medical progress during these past few years. Present preparations by our Medical Department should counteract a repetition of the surprises which occurred during the last World War; surprises such as the great epidemics of influenza and typhus fever—the latter with its mortality of about 5,000,000 among an estimated 10,000,000 cases.

We may encounter hydatid diseases in certain latitudes; malaria and yellow fever in others. We must be quick to think of schistosomiasis when confronted with hepatomegaly and splenomegaly together with evidence of venous engorgement such as esophageal varices. We must recall the writings of Golden and his co-workers relative to filariasis, with its roentgen evidence of localized edema and soft tissue calcifications. We must be alert to recognize the roentgen signs of Cooley's anemia and sickle-cell anemia.

As for the gastro-intestinal tract, we must be conscious of the manifestations of sprue, hookworm disease, and amebiasis. We must be acquainted with the high incidence of carcinoma of the esophagus among the Chinese; the high proportion of car-

cinoma of the liver in tropical peoples, as well as the high incidence of sarcoma in the Pacific islands. There will be cardiac manifestations of beri-beri and of periarteritis nodosum. Suspected peptic ulcers may be revealed as tropical scurvy.

These are but a few of the problems. You may say that the roentgenologist is not solely responsible, but I would remind you that in certain medical installations the roentgenologist is the sole diagnostician, and I am sure you will agree that, in both civilian and military hospitals, he comes in contact with the greatest variety of cases, probably more than any other single consultant. It is a matter of practical importance that we radiologists become cognizant of this wider expanse of the medical field opened by the movement of our military personnel to and *from* all corners of the globe.

The bacterial and parasite foes which we face are of an alarming type. They are stealthy, insidious in their aggression. They do not attack with the raucous approach characteristic of man. Though they are less spectacular in the beginning of their conquest, their progress may be far more destructive than that which is accomplished by our human foes.

This is indeed an interesting era. Medically, it calls for the highest degree of diagnostic alertness. We must read of developments; we must think of ever-changing conditions and, if we would help one another in caring for our entire populace, we must describe in detail such strange findings as we encounter.

ANNUAL MEETING, 1943 RADIOLOGICAL SOCIETY OF NORTH AMERICA

Members of the Radiological Society of North America will be happy to learn that arrangements are already being made for the Annual Meeting in 1943. The dates are Nov. 29 to Dec. 3 and the place the Drake Hotel, Chicago.

That war need not interfere with the success of such gatherings, but indeed enhances the importance of the free interchange of scientific ideas, was amply proved by the 1942 sessions. We look forward to an equally profitable meeting in 1943.

Many, recalling the excellence of the arrangements at the Drake Hotel, will be glad to know that it has again been chosen as the place of meeting.

TWENTY WAR SESSIONS AMERICAN COLLEGE OF SURGEONS

There has been arranged under the sponsorship of the American College of Surgeons, with the cooperation of other medical organizations and of the Federal medical services, a series of twenty regional war sessions to be held in various cities throughout the United States. Each session occupies a full day, from 9:00 A.M. to 10:00 P.M., including luncheon and dinner conferences.

According to the announcement of these sessions: "Topics to be discussed relating to military medicine will include care of the ill and injured in combat zones and after evacuation. The newer types of injuries encountered in this war, such as crush and blast injuries, will be especially considered, together with prevention and treatment of infections and treatment of burns, shock, and injuries of specific parts of the body. Anesthesia, plastic surgery, and the psychoneuroses of war will be some of the other topics. Problems of civilian medical care in wartime which will be discussed will include the responsibilities of individual doctors and hospitals; personnel problems of hospitals; organization of emergency medical services; maintaining adequate supplies, furnishings, and equipment; maintenance of high standards of medical and nursing education, and of hospital service in general; hospital public relations; and administrative adjustments in professional staffs of hospitals. The opening meeting of each session will be devoted to discussion of 'Medical and Surgical Aspects of Chemical Warfare', led by a representative of the United States Office of Civilian Defense, and the closing meeting will be a panel discussion on problems in wartime civilian medical practice to be led by representatives of the United States Public Health Service, the American College of Physicians, the American Medical Association, medical services in industry, and the American College of Surgeons."

The first of the sessions, that at St. Paul, was held on March 1. Others have been held in Milwaukee, Indianapolis, Detroit, Pittsburgh, Buffalo, and Boston. Those still to be held are as follows:

Brooklyn, N. Y. (St. George Hotel), March 17
Richmond, Va. (John Marshall Hotel), March 19
Charlotte, N. C. (Charlotte Hotel), March 22
Birmingham, Ala. (Tutwiler Hotel), March 24
Memphis, Tenn. (Peabody Hotel), March 26
Houston, Texas (Rice Hotel), March 29
Kansas City, Mo. (President Hotel), April 1
Omaha, Neb. (Fontenelle Hotel), April 3
Denver, Colo. (Cosmopolitan Hotel), April 6
Salt Lake City, Utah (Utah Hotel), April 9
Los Angeles, Calif. (Biltmore Hotel), April 13
San Francisco, Calif. (Fairmont Hotel), April 16
Seattle, Wash. (Olympic Hotel), April 20

CHILDREN'S TUMOR REGISTRY

Announcement has recently been made of the establishment, under the auspices of the American Academy of Pediatrics, of a Children's Tumor Registry at the Memorial Hospital for the Treatment of Cancer and Allied Diseases, New York.

All hospitals, clinics, and members of the medical profession are urged to submit preliminary data on tumors believed to be malignant, in children less than 15 years of age. Data should be addressed to the Memorial Hospital for the Treatment of Cancer and Allied Diseases, 444 East 68th St., New York.

In Memoriam

It is with sincere regret that we announce the death of the following members of the Radiological Society of North America, in recent months:

FRANK HAMLIN BLACKMARR, M.D.
Chicago, Ill.
Sept. 16, 1942

WILBUR SAMUEL HAMILTON, M.D.
San Antonio, Texas
Aug. 27, 1942

SAMUEL GILMORE LOGAN, M.D.
Ridgeway, Penna.
Dec. 21, 1942

HUGH DUNCAN McGAUGHEY, M.D.
Joplin, Mo.
Aug. 13, 1942

ELMER GRANT WEIBEL, M.D.
Erie, Penna.
Sept. 19, 1942

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

ATLAS OF OVARIAN TUMORS. By GEMMA BARZILAI, M.D. New York City. Preface by FRED W. STEWART, M.D., Pathologist, Memorial Hospital for the Treatment of Cancer and Allied Diseases, New York City. A volume of 264 pages with 258 original illustrations, 45 in colors on 58 plates. Published by Grune & Stratton, 443 Fourth Ave., New York, N. Y. Price (cloth) $10.00.

THE PERIODICITY AND CAUSE OF CANCER, LEUKEMIA AND ALLIED TUMORS, WITH CHAPTERS ON THEIR TREATMENT. By J. H. DOUGLAS WEBSTER, M.D., F.R.C.P.E., F.F.R., Honorary Director, Meyerstein Institute of Radiotherapy, Middlesex Hospital, London, W.1; Lecturer and Examiner in Radiotherapy, Faculty of Radiologists, London. Published by Baillière, Tindall and Cox, London, 1940. Price $3.50.

Book Reviews

A MANUEL OF RADIOTHERAPY. By MURRAY M. FRIEDMAN, M.D., Assistant Professor of Radiology, College of Physicians and Surgeons, Columbia University; Assistant Radiologist, Presbyterian Hospital, New York. A paper-bound, lithoprinted volume of 86 pages with 30 illustrations. Published by Edwards Brothers, Inc., Ann Arbor, Mich., 1942. Price $1.50.

This book is written in outline form and covers the basic technic of x-ray and radium therapy employed in the department of Radiology of the Presbyterian Hospital of New York in a variety of conditions, neoplastic and non-neoplastic, malignant and benign. Each condition is considered separately with a brief presentation of the clinical picture, the probable radiotherapeutic response, the technic used, and a short bibliography. A section on radium dosage is also included.

This excellent outline should be of real service for rapid reference. The author wisely stresses the fact that it is only a guide, that a rigid formulary cannot take the place of experience, and that individualization of treatment is essential.

OCCUPATIONAL TUMORS AND ALLIED DISEASES. By W. C. HUEPER, M.D., Assistant Director and Principal Pathologist, Warner Institute for Therapeutic Research, New York City. A volume of 896 pages. Published by Charles C Thomas, Springfield, Illinois, 1942. Price $8.00.

The scope of this textbook, planned to be a detailed treatise on occupational blastomas and allied diseases, may be exemplified by the subject index of 46 pages or by a sample bibliography, as, for example, that on tumors of the skin, totalling about 150 citations. Information about induced tumors has been compiled from world-wide sources and is here made available to all those directly or indirectly associated with the supervision of public health, the minimizing of industrial hazards, or the diagnosis and treatment of tumors. All this information is correlated into fourteen chapters totalling 850 pages.

One hesitates to pick out from such a wealth of information a specific subject for mention. Nevertheless, the section on tumors of the skin and the role of injury from the careless or indiscriminate use of x-rays or the radioactive substances in the production of cancer should appeal especially to the radiologist. Of perhaps equal interest is the chapter on diseases of the blood-forming organs.

Not only does the author discuss the part of many and varied agents in the production of malignant tumors, but he also indicates how their role may be minimized or nullified, and in this connection describes legal means taken throughout the world to that end. Every time one reads this book, he finds something new, interesting, and important. Its appeal is not only to physicians, but also to chemists, biologists, pathologists, research workers, industrialists, and lawyers. There is no doubt that this is *the* authoritative standard.

RADIOLOGICAL SOCIETIES OF NORTH AMERICA

Editor's Note.—Will secretaries of societies please co-operate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Building, Syracuse, N. Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill.

Section on Radiology, American Medical Association — Secretary, J. T. Murphy, M.D., 421 Michigan St., Toledo, Ohio.

ARKANSAS

Arkansas Radiological Society.—Secretary-Treasurer, J. S. Wilson, M.D., Monticello. Meets every three months and annually at meeting of State Medical Society.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Joseph D. Coate, M.D., 434 Thirtieth St., Oakland.

Los Angeles County Medical Association, Radiological Section.—Secretary, Donald R. Laing, M.D., 65 N. Madison Ave., Pasadena. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Secretary-Treasurer, L. Henry Garland, M.D., 450 Sutter St., San Francisco. Society meets annually during annual meeting of the California Medical Association.

San Francisco Radiological Society.—Secretary, Earl R. Miller, M.D., University of California Hospital. Meets monthly on third Thursday at 7:45 P.M., for the first six months at Toland Hall (University of California Medical School); second six months at Lane Hall (Stanford University School of Medicine).

COLORADO

Denver Radiological Club.—Secretary, Edward J. Meister, M.D., 366 Metropolitan Bldg. Meetings third Friday of each month at the Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology. —Secretary-Treasurer, Max Climan, M.D., 242 Trumbull St., Hartford. Meetings bimonthly, on second Thursday. Place of meeting selected by Secretary.

FLORIDA

Florida Radiological Society.—Acting Secretary, Walter A. Weed, M.D., 204 Exchange Building, Orlando.

GEORGIA

Georgia Radiological Society. — Secretary-Treasurer, James J. Clark, M.D., 478 Peachtree St., N. E., Atlanta. Meetings twice annually, in November and at the annual meeting of State Medical Association.

ILLINOIS

Chicago Roentgen Society.—Secretary, Warren W. Furey, M.D., 6844 S. Oglesby Ave. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Fay H. Squire, M.D., 1753 W. Congress St., Chicago.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, M.D., Methodist Hospital, Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Sydney E. Johnson, M.D., Louisville City Hospital, Louisville. Meeting annually in Louisville, third Saturday afternoon in April.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society.

Shreveport Radiological Club.—Secretary-Treasurer, R. W. Cooper, 940 Margaret Place. Meetings monthly on the second Wednesday, at the offices of the various members.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Walter L. Kilby, M.D., 101 W. Read St. Meetings are held the third Tuesday of each month.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave., Detroit.

Michigan Association of Roentgenologists.—Secretary-Treasurer, E. M. Shebesta, M.D., 1429 David Whitney Bldg., Detroit. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—Secretary, John P. Medelman, M.D., 572 Lowry Medical Arts Bldg., St. Paul. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—Secretary, Arthur B. Smith, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—Secretary, Paul C. Schnoebelen, M.D., 462 N. Taylor Ave. Meets on fourth Wednesday of each month except June, July, August, and September, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—Secretary, F. L. Simonds, M.D., 1216 Medical Arts Bldg., Omaha. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society (Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island).—*Secretary,* Hugh F. Hare, M.D., Lahey Clinic, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. J. Perlberg, M.D., Trust Co. of New Jersey Bldg., Jersey City. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—Secretary, William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo Harrington, M.D., 880 Ocean Ave. Meetings held the fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gianfranceschi, M.D., 610 Niagara St. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Ray Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings are held in January, May, and October, as called by Executive Committee.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Maurice Pomeranz, M.D., 1120 Park Ave., New York, N. Y.

Rochester Roentgen-ray Society.—Secretary, S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meeting with State meeting in May, and meeting in October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, L. A. Nash, M.D., St. John's Hospital, Fargo. Meetings by announcement.

OHIO

Ohio Radiological Society.—Secretary, J. E. McCarthy, M.D., 707 Race St., Cincinnati. The next meeting will be held at the time and place of the annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, J. O. Newton, M.D., 13921 Terrace Road, East Cleveland. Meetings at 6:30 P.M. at the Mid-day Club, in the Union Commerce Bldg., on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*Secretary-Treasurer,* Samuel Brown, M.D., 707 Race St. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport. The Society meets annually.

The Philadelphia Roentgen Ray Society.—Secretary, Robert P. Barden, M.D., 3400 Spruce St., Philadelphia. Meetings held first Thursday of each month at 8:15 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22nd St., Philadelphia.

The Pittsburgh Roentgen Society.—Secretary-Treasurer, Reuben G. Alley, M.D., 4800 Friendship Ave., Pittsburgh, Pa. Meetings are held on the second Wednesday of each month at 4:30 P.M., from October to June, at the Pittsburgh Academy of Medicine, 322 N. Craig St.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston. Meeting in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—Secretary-Treasurer, Herman Klapproth M.D., Sherman.

VIRGINIA

Virginia Radiological Society.—Secretary E. Latané Flanagan, M.D., 215 Medical Arts Bldg., Richmond.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Kenneth J. Holtz, M.D., American Bank Bldg., Seattle. Meetings fourth Monday of each month at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary-Treasurer, C. A. H. Fortier, M.D., 231 W. Wisconsin Ave., Milwaukee. Meets monthly on second Monday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russell F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

CANADA

Canadian Association of Radiologists.—Honorary Secretary-Treasurer, A. D. Irvine, M.D., 540 Tegler Bldg., Edmonton, Alberta.

La Société Canadienne-Française d'Electrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meetings are held the third Saturday of each month, generally at the Radium Institute, 4120 East Ontario Street, Montreal; sometimes, at homes of members.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meetings are held monthly.

ABSTRACTS OF CURRENT LITERATURE

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Hyperostosis Frontalis Interna. C. T. Andrews. Brit. M. J. **2:** 185–187, Aug. 15, 1942.

The author gives a concise but illuminating account of the condition known as hyperostosis frontalis, with a discussion of the symptomatology and a record of one case. Attention is called to 5 fatal cases recorded by Stewart (J. Neurol. & Psychopath. **8**:321, 1928) associated with mental symptoms and obesity.

The condition is most apparent in a lateral film, where irregular projections of bone are noted in the inner table of the frontal region in the mid-line. The symptoms are persistent headache, cataleptic seizures, tendency to obesity, and mental changes consisting of delusions, hallucinations, and narcolepsy. Nearly all the patients are females and there is a frequent association with diabetes. The predominant age incidence is around the menopause. One patient gave a history of headache for thirty years.

Cases of hyperostosis frontalis without symptoms have been observed. The importance of the syndrome lies in its differentiation from conditions requiring active medical or surgical intervention.

Andrews' paper provoked the report of another case of hyperostosis frontalis interna by H. Ucko, in the Correspondence columns of the British Medical Journal, Oct. 3, 1942, page 408. A roentgenogram showing the hyperostotic changes is reproduced.

Q. B. Coray, M.D.

THE CHEST

Pulmonary Agenesia; Report of 3 Cases and General Review of the Literature. A. Castellanos and R. Pereiras. Bol. Soc. cubana de pediat. **14:** 268–330, June 1942.

In addition to reporting 3 cases of pulmonary agenesia, or absence of a lung, the authors present an exhaustive review of the literature. Up to 1941 only 50 cases had been reported and in only 6 of these was the diagnosis made before death.

For correct diagnosis the authors stress the value of bronchography and angiocardiography to demonstrate the absence of the lung structures and show the presence of the heart in the thoracic cavity where the absent lung should have been. They believe that plain radiography only confirms what is found on physical exploration. Bronchoscopy is considered helpful, as the bronchus on the affected side may be seen terminating in a pouch. Pneumothorax and kymography are useful adjuncts, the former to demonstrate a small pleural cavity, the latter the position of the heart.

The article is well illustrated and detailed. It is particularly recommended to those having a special interest in pediatrics.

A. Mayoral, M.D.

Fugitive Lung Infiltration. R. Staehelin. Schweiz. med. Wchnschr. **72:** 785–788, July 18, 1942.

There are several types of pulmonary infiltrate or exudate which can be described as "fugitive." The rarest is the eosinophilic exudate of Löffler. In this condition nodular shadows suddenly appear and vanish in a few days without any clinical evidence of illness. Several types of morphology are described, and the infiltration usually vanishes in three to eight days. An eosinophilia of the blood (up to 66 per cent) may be observed. The general health is almost normal, and physical findings are vague or absent. The condition is not sufficiently well characterized to be readily distinguished clinically from minimal tuberculosis. The cause of this condition is thought to be an allergic manifestation toward ascarides, the larvae of which burrow through the intestinal walls and wander into the lungs.

Tuberculous infiltrates can be divided into four groups: (1) resorption without residua, except possibly a small calcified scar; (2) healing with scarring, seen on the roentgenogram as a spotty or reticular shadow; (3) progress to caseous pneumonia; (4) appearance of cavities. A fugitive infiltrate can be known certainly as tuberculous only if it changes to a progressive form of the disease. It is desirable to subject all patients to roentgen study as a guide to treatment, since the disease readily changes to a progressive form even though the symptoms seem benign.

Many pneumonias produce a transitory infiltration. It is important to remember that in these the physical findings do not parallel the roentgen picture. Many more cases of atypical pneumonia are now being seen, and in these roentgen study is necessary. In some of these cases a positive Wassermann reaction is observed, which becomes negative on recovery. Grumbach investigated these cases and concluded that they were caused by the Pfeiffer bacillus.

Other conditions to be considered in differential diagnosis are lung abscess, mediastinal tumors, enlargement o the mediastinal nodes, and dermoid cysts. These conditions are readily distinguished by their course, although they may cause confusion at first. Lung infarction may produce transitory shadows. Lung tumors may be an important source of diagnostic error, since early nodular metastases may resemble an early infiltrate. The edema around them may disappear, suggesting regression on the x-ray film. Focal atelectases may produce a similar picture.

It is often impossible to make an accurate diagnosis from the roentgenogram, especially if one has not had extensive experience. Löffler believes the diagnosis can be made only by fluoroscopy, but sufficient accommodation (at least ten minutes) is essential.

Lewis G. Jacobs, M.D.

Chronic Lung Infiltrate with Eosinophilia. M. Kartagener. Schweiz. med. Wchnschr. **72:** 862–864, Aug. 8, 1942

Löffler's observation in 1931 of a fugitive pneumonia accompanied by eosinophilia has been confirmed by other authors throughout the world. The etiology of the condition has not been clarified, however. Symptomatically the condition is well defined, the benign course being the most characteristic finding; the fleeting character of the lung infiltrate is to be observed both clinically and radiologically. The maximum eosinophilia appears several days after the maximum lung findings, and may reach very high levels (to 70 per cent). The recession of the lung signs

may be delayed (edema? atelectasis?), or secondary infection may occur. This may be designated Löffler's type.

A second type, Löhr-Léon-Kindberg's type, is characterized by a dissociation of symptoms and findings. This type follows a very acute, almost septic course. A third type, characterized by extreme chronicity, is also seen.

In differential diagnosis constitutional eosinophilia, asthma, asthmatic bronchitis, lymphogranulomatosis, echinococcus disease, ascariasis, bilharziasis, and tuberculosis must be considered. The polymorphism of the lung changes suggests that the disease has an allergic background. LEWIS G. JACOBS, M.D.

Recognition of Virus Type Pneumonia. B. E. Goodrich and H. A. Bradford. Am. J. M. Sc. **204:** 163-179, August 1942.

Various investigations indicate a virus agent, dissimilar to other standard virus strains, for the type of pneumonia described in this paper. Most of the authors' 52 patients were young adults who had been in good health previously. The onset was usually insidious, with the development of a cough which eventually became productive, associated with some discomfort in the chest. While chilliness was occasionally observed, frank chills were rare. Headache, though often a complaint at the onset, occasionally assumed distressing proportions. Mucopurulent sputum was usually present, though in one-fourth of the cases the amount of sputum was insignificant. A variable degree of fever, ranging from 100° to 103°, was seen in patients moderately ill, but in the severe cases the temperature rose somewhat above this. It varied widely during the twenty-four-hour period, the lowest temperature each day approaching normal. Very few patients showed high plateaus of fever. The duration of the fever was from eleven days in mild cases to twenty-nine days in severe cases. The pulse was usually disproportionately slow on admission. The white cell count was below 8,000 in 55 per cent of the cases; higher counts were occasionally seen. Sputum typing rarely revealed pneumococci.

Radiographically, the milder cases usually showed less extensive pulmonary infiltration. The character of the roentgen findings varied, including patchy bronchopneumonic areas, fine hazy infiltrates involving half a lung, widespread miliary infiltrations, and dense consolidations resembling lobar pneumonia. The infiltrations tended to migrate; in almost one-half of the cases both lungs were ultimately involved. The differentiation from tuberculosis was often impossible in the early cases. The duration of the roentgen evidence of disease tended to parallel the degree of illness.

From cases in which exposure could be traced, it was determined that the incubation period averaged 18.7 days.

Symptomatic treatment was instituted. Blood transfusions given to the severely ill patients produced no constant response. The sulfonamide drugs were of no value. It has been stated that this disease, which has been differentiated from influenza, appears to increase the resistance of the patient to the pyogenic organisms. BENJAMIN COPLEMAN

So-Called Interstitial Plasmocytic Pneumonia in Infants. F. and W. Stirnimann. Schweiz. med. Wchnschr. **72:** 910-914, Aug. 22, 1942.

Lately there has been a new disease among infants which, on the basis of pathologic-anatomical findings, may be termed interstitial plasmocytic pneumonia. Although the condition was observed only occasionally from 1935 to 1940, a serious increase appeared in the fall of 1941. The authors observed 5 cases, with 4 deaths. In all of these latter the diagnosis was proved histologically. All the patients were well developed, previously healthy children of two to two and a half months.

The outstanding symptom was a "grunting respiration." Expiration was prolonged, especially at the end, producing an audible grunt. There was no stridor. Some retraction of the intercostal spaces was present, and the auxiliary muscles of respiration were used. The nares were expanded and a massive cyanosis was present, with a respiratory rate of 80 to 100 per minute. Percussion gave a hyperresonant note, with diminished cardiac dullness. No râles or rhonchi were heard on auscultation. The temperature was at first normal, but later rose to subfebrile levels, between 37.8° and 37.9° C. It became subnormal later, if collapse supervened.

Laboratory findings were a diminished red count and a moderate leukocytosis. The roentgenogram showed faint nodular, at times confluent, infiltrations in the lungs.

The fatal cases had a course of four, five, and seven days; the recovered case of fourteen days. Treatment was at first limited to cardiac stimulants; later, when the course was better understood, sedatives were used.

Although previous writers have considered this a condition of debilitated infants, the observations in the current series suggest that it represents a special type of reaction in the newborn to an infection which, in an older child, would produce an ordinary bronchopneumonia. Previous upper respiratory infection was not demonstrated in any of these patients.

LEWIS G. JACOBS, M.D.

Atelectasis and Bronchiectasis: Experimental Study Concerning Their Relationship. J. Tannenberg and M. Pinner. J. Thoracic Surg. **11:** 571-616, August 1942.

A possible causative relationship between atelectasis and bronchiectasis has been considered since 1885. The authors have attempted a clarification of the causative role that atelectasis is believed to play in the development of bronchiectasis. Their work consists of a large number of animal experiments in which bronchial obstruction was produced in rabbits.

In the first group of rabbits atelectasis was produced in 28 animals by occlusion of the main bronchus to one lung by plugging it from within. In 10 rabbits a simultaneous pneumothorax was maintained on the side of the obstructed bronchus. X-ray evidence of atelectasis developed within an hour and was complete in one instance in three hours. In some rabbits the obstruction was removed after seven to ten days, whereupon the lungs re-expanded and became normal. In all but 3 of the animals which survived long enough for satisfactory study, some degree of infection de-

veloped. Bronchial dilatation was found in some rabbits as early as the fifteenth day. Extensive bronchiectasis was present after twenty-five days. Pneumothorax on the side of the bronchial obstruction did not prevent the development of bronchiectasis. Three rabbits showed a normal lung after having the bronchi obstructed for thirty-two, forty-two, and eighty-nine days respectively; there was no atelectasis or bronchiectasis. In these 3 animals the bronchial obstruction, although quite marked, was found post-mortem to be not quite complete.

In another group, consisting of 25 rabbits, the main bronchus was obstructed by external ligation. Atelectasis developed in twenty minutes. In 12 of the animals a pneumothorax was maintained on the side of the obstruction. No bronchiectasis developed in the absence of a complicating infection. In 6 rabbits there was a moderate bronchiectasis, thought to be due partly to associated infection. In one instance fibrosis of the lung developed in three months, also presumably due to infection. In another series infectious material was placed in the bronchus prior to ligation. Five animals lived more than a few days, and in all of these severe bronchiectasis developed.

In another group the pulmonary artery was ligated and gradual shrinkage of the lung developed, without bronchiectasis except when infection was also introduced.

In the last group a bronchus was partially closed by ligation. No bronchiectasis developed in this series. A patchy atelectasis with areas of emphysema was observed.

The authors conclude that uncomplicated pulmonary atelectasis cannot produce bronchiectasis even when the main bronchus is wide open, as in the cases of ligation of the pulmonary artery. On the other hand, a complicating infection may produce severe bronchiectasis in three or four weeks. Infections without some degree of bronchial obstruction did not produce bronchiectasis. The cause of bronchiectasis in these experiments is inflammatory infiltration of the bronchial walls, with accumulation of exudate in the bronchial lumina; the latter is prevented from draining because of the artificially produced bronchial obstruction.

HAROLD O. PETERSON, M.D.

Acute Putrid Pulmonary Abscess: Criteria of Cure. A. S. W. Touroff and H. Neuhof. Am. Rev. Tuberc. **46:** 121–125, August 1942.

Remission is common at some time during the acute stage of putrid pulmonary abscess. Amelioration of symptoms may be progressive, with termination in cure, or the improvement may be only temporary and the subsequent clinical course one of varied severity. Regardless of the improvement of clinical manifestations, it is a serious error to consider the patient cured unless a roentgenogram of the chest reveals disappearance not only of the abscess cavity but also of all pulmonary infiltration. It is emphasized that the disappearance of a fluid level alone does not necessarily signify the disappearance of a cavity. The two roentgenographic criteria of cure of acute pulmonary abscess are, first, the disappearance of cavity and, second, the disappearance of all surrounding pulmonary infiltration. If pulmonary infiltration persists in the region of the previously noted cavity, cure cannot be assumed to have taken place, regardless of the mildness or even the absence of clinical manifestations.

In occasional cases an abnormal shadow may appear in the film after the patient is free of symptoms and the cavity and pulmonary infiltration have disappeared. Such shadows are observed not infrequently in cases which have been subjected to operation and consist of clusters of clearly delineated strands between which normal pulmonary illumination is seen. The authors believe that these represent areas of fibrosis or scarring in the region of healed cavities, and such a scar should not be confused with the homogeneous, more diffuse, and more irregular shadow cast by areas of active pulmonary inflammation.

Whenever there is any question as to whether the lesion under suspicion represents an old scar or a residual inflammatory process, diagnostic bronchoscopy should be performed. If purulent secretion is encountered, cure cannot be considered to have occurred, regardless of the absence of clinical manifestations and the otherwise favorable appearance of the roentgen film. If the secretion is minimal and is not foul, it may be assumed that infection is subsiding, but the patient should be kept under observation until the diagnosis is clarified.

L. W. PAUL, M.D.

A Tuberculosis Case-Finding Demonstration in San José, Costa Rica. C. W. Wells. Am. Rev. Tuberc. **46:** 179–186, August 1942.

The author describes a tuberculosis case-finding demonstration conducted in San José, Costa Rica. The procedure comprised a fluoroscopic examination of the chest, supplemented by roentgenography with regular-size film in all positive or suspicious cases. To permit fluoroscopic examinations without aid of a dark room, a special hood of light-weight material was attached to the fluoroscope frame and provided with a suitable cap to fit over the head of the examiner. A total of 27,760 persons were examined, and about 2 per cent of all fluoroscopic examinations were followed by radiographic study with a mobile unit. Chief attention was concentrated on the detection of lesions which might prove upon further study and examination to be significant.

The occurrence of active tuberculosis, including cases with caseous lymph nodes, was found to be 0.9 per cent among those examined. The survey was conducted in an area comprising 71 city blocks with a population of 20,125, of which 91.7 per cent were examined. The survey demonstrates the possibility as well as the practicability of examining a high percentage of the population when a diagnostic service is taken to the people and when their time and convenience are considered.

L. W. PAUL, M.D.

Undiagnosed Pulmonary Tuberculosis in Elderly Persons. R. E. Miller and B. Henderson. Am. Rev. Tuberc. **46:** 164–171, August 1942.

There is evidence that tuberculosis in later life frequently escapes recognition and that such a patient may act as a spreader of the disease in the community for many years. The best method of finding the elderly spreader of tuberculosis would seem to be through the use of the mass x-ray survey. The survey described in this paper was undertaken as part of the

New York City program and in order to study the incidence of undiagnosed pulmonary tuberculosis at various age levels. The group contained persons of all ages. A total of 3,414 persons were x-rayed; 42 per cent of these were native-born whites; 57.7 per cent were foreign-born whites; 0.3 per cent were Negroes, Puerto Ricans, or Chinese. It was found that 10.63 per cent of all males examined and 6.36 per cent of all females had chronic pulmonary tuberculosis, while 4.55 per cent of males and 1.67 per cent of females had significant tuberculosis.

Examination of the material presented reveals that, in the group studied, all forms of reinfection pulmonary tuberculosis were more common in the elderly than in the young. Males showed a higher percentage of tuberculosis at all ages than did females. Of the 13 persons who were found to have positive sputum, 12 were above the age of fifty. None of the 13 had marked symptoms at the time of discovery, and some of them have remained relatively symptom-free during almost two years of observation, even though they have continued to expectorate tubercle bacilli.

The authors believe more attention should be paid to the examination of these elderly patients with mild pulmonary symptoms which often are attributed to chronic bronchitis, asthma, or some other minor chronic pulmonary disorder of the aged.

L. W. PAUL, M.D.

Allergic Myocarditis and Nephritis in a Case of Tuberculous Hilar Adenitis. J. Flagg and M. Froehner. Schweiz. med. Wchnschr. **72:** 922–924, Aug. 22, 1942.

An acute nephritis of benign course appeared in a recruit twenty years of age. Radiography showed gross hilar adenopathy and on two occasions gross dilatation of the heart, while the electrocardiogram indicated myocardial damage. There were a recurring conjunctivitis and slight anemia. Of all these findings, only the hilar adenopathy was persistent. The author feels that the only explanation lies in the assumption of a breakdown of the hilar nodes with a severe allergic reaction to the resulting material.

Wohlhueter has shown that cardiac enlargement —what he terms a "toxic heart"—may complicate pulmonary or pleural tuberculosis. This is a cardiac dilatation which may appear very suddenly, and which shows a parallelism to the changes in the lung or pleura. This parallelism is thought to be present in the case reported.

[Since this patient did not come to necropsy, and since he was followed only about five months, it seems that hardly enough attention is given to the possibility of an infectious nephritis of coccic origin in a patient who happened to have hilar node enlargements. Since "allergy" is now used to cover a multitude of poorly explained phenomena, it would be desirable to have conditions so classified thoroughly authenticated. L. G. J.]

LEWIS G. JACOBS, M.D.

Erythema Nodosum. M. H. Poppel and A. M. Melamed. New England J. Med. **227:** 325–330, Aug. 27, 1942.

This is an analysis of 88 cases of erythema nodosum seen between 1928 and 1941. The condition was formerly thought to be a tuberculid but the present evidence points toward a response to some toxic complex arising in the course of various conditions. Erythema nodosum is most common in young females, especially in the spring months. Under three years and in old age the condition is rare. In some countries the incidence of erythema nodosum with tuberculosis is high, but in this country rheumatic fever, streptococcal infections, and in the San Joaquin Valley coccidioidomycosis are more common accompaniments.

Grossly the lesion is a discrete, firm, hot, tender, conical nodule about 1 to 5 cm. in diameter, symmetrically distributed, usually on the anterior aspect of the legs, less often on the forearms, arms, thighs, buttocks, and face. The surface is glossy and the color varies from a bright red to a deep purple. Upon involution the lesion resembles a bruise or contusion.

An analysis of the authors' cases shows 13 in which there was no associated disease. Concomitant conditions in the remaining cases included rheumatic fever, upper respiratory infection, arthralgia, ulcerative colitis, drug ingestion, syphilis, gonorrhea, herpes zoster, measles complicated by otitis media, eye infections, peritonsillar abscess, prostatic abscess, postoperative infection, and axillary abscess. Chest films were available in 56 of the 88 patients, of which 14 showed deviations from normal. Mediastinal or hilar nodes were enlarged in 12 instances and 3 of these showed calcifications. Resolving pneumonia, childhood tuberculosis, miliary tuberculosis and fibrocalcific tuberculosis were each seen once.

This study fails to reveal any characteristic pulmonary changes in erythema nodosum in a series of 88 cases. Such chest changes as were seen could be otherwise accounted for. It is suggested that the chest of every patient with erythema nodosum be studied roentgenologically and that a lateral view be made in addition to the routine anteroposterior film.

JOHN B. MCANENY, M.D.

Carcinomas of the Lungs of Extrathoracic Development, with Report of a Case. N. Puente Duany. Rev. med. cubana **53:** 427–431, May 1942.

Puente Duany reports and discusses a case of pulmonary neoplasm presenting the clinical and pathological findings so well described by Pancoast in 1932 under the designation superior pulmonary sulcus tumors. The lesion was located in the right apex, extending to the soft tissue and destroying the neighboring bony structures. Horner's syndrome, so helpful in the diagnosis of these tumors, was an early finding.

A. MAYORAL M.D.

Interauricular Septal Defect. W. S. Tinney and A. R. Barnes. Minnesota Med. **25:** 637–643, August 1942.

Slight patency of the foramen ovale or an opening of sufficient size to permit passage of a probe is the commonest of all congenital cardiac defects, and is of no clinical significance except in some cases of terminal myocardial failure with increased pressure in the right auricle, a condition under which it may give rise to paradoxical embolism or to terminal cyanosis. Defects 1 cm. in diameter or larger are, however, true congenital malformations rarely diagnosed clinically and only infrequently found postmortem.

Four cases of the latter type have been reported previously from the Mayo Clinic, the first in 1926. In 1934 Roesler (Arch. Int. Med. **54**:339, 1934) made a complete review of the literature on the subject and reported a case of his own; in 1940 Tinney reviewed the literature in the intervening period and reported two new cases (Arch. Int. Med. **66**:807, 1940). The total number recorded to date appears to be 86.

The authors present in full detail 4 cases of their own. The first was interesting because the congenital lesion was complicated by mitral stenosis, regurgitation, and auricular fibrillation. In their comment on this case the authors say: "Interauricular septal defect is the only congenital lesion frequently associated with mitral endocarditis or auricular fibrillation. Because of the presence of mitral stenosis this case is an example of the so-called Lutembacher's disease."

In the second case, a clinical diagnosis of congenital heart disease was made on the basis of the history of a murmur since infancy, enormous hypertrophy of the right side of the heart, and the presence of a large pulmonary conus. Since the septal defect was associated with mitral stenosis, this is also an example of Lutembacher's disease. By far the most interesting aspect of the case was the presence of subacute bacterial endocarditis, an unusual complication of interauricular septal defects. To the knowledge of the authors, this is the second case reported in which the vegetations involved the septal lesion.

In the third case the heart lesion was an incidental finding following death from an entirely unrelated condition. Neither the history nor physical findings in the fourth case are of special interest.

Interauricular septal defect is the result of failure of development and union of the three embryonic anlagen: the endocardial cushions, the septum primum, and the septum secundum. The defect produces several characteristic findings: dilatation of the right auricle and ventricle, with hypertrophy; relative smallness of the left auricle and ventricle; dilatation and hypertrophy of the pulmonary artery to such a degree that it is almost always larger than the aorta.

Since the pressure within both auricles is practically equal, there is no reason to believe that there is very much admixture of blood in spite of a defect in the septum. When the defect is complicated by mitral stenosis, the pressure in the left auricle is higher than in the right and there is an arterial to venous shunt. Therefore, if in the absence of congestive failure there is any appreciable admixture of blood, it is from the arterial to the venous side, and cyanosis does not occur. If, however, an additional burden is suddenly placed on the right side of the heart by increasing the pulmonary pressure, there frequently develops a so-called effort-cyanosis because the hemodynamic mechanism is temporarily changed, causing a shunt from the venous to the arterial side. This congenital defect has been designated *cyanose tardive*, because permanent cyanosis is present usually only in the very late stages. Clubbing rarely is observed. A deformity of the left side of the thorax usually is present.

Thrills may or may not be observed. The most frequent finding is a murmur that may simulate closely that heard in interventricular septal defect, but is not so constant, is usually higher, and less intense. This systolic murmer is heard best, as a rule, in the second or third interspace just to the left of the sternum. Clinically the heart is enlarged both to left and right. Pulsation of the liver and the cervical veins is frequently observed.

According to Graybiel and White (Electrocardiography in Practice, W. B. Saunders Co., 1941) the right ventricular preponderance seen in the electrocardiogram is marked, being comparable to that seen in two other conditions: congenital dextrocardia and tetralogy of Fallot. Auricular fibrillation is frequent.

The only constant and reliable antemortem findings are those elicited by roentgenographic and roentgenoscopic examinations, which reveal an enlarged, globular heart (most of the enlargement being in the right auricle and right ventricle), a very small aortic knob, a greatly enlarged pulmonary arch, and wide hilar shadows that frequently pulsate. Occasionally these enlarged hilar vessels are erroneously diagnosed tuberculosis, aneurysm, or tumor.

PERCY J. DELANO, M.D.

THE DIGESTIVE TRACT

Rare Roentgen Findings in the Region of the Digestive Tract. H. Gysin. Schweiz. med. Wchnschr. **72**: 841–846, Aug. 1, 1942.

Four cases are reported to illustrate plausible errors of roentgen diagnosis. In the first a defect in the duodenum, interpreted as a diverticulum or possible neoplasm, was found to be a pocket where a carcinomatous lymph node (metastatic from the uterine cervix) had eroded into the organ.

The second patient was an alcoholic with cardiac decompensation. Chest studies showed a serosanguineous effusion on the right with a heavy homogeneous shadow in the base. The liver was large and the duodenal bulb constantly deformed. At necropsy a bronchogenic carcinoma and cirrhosis of the liver were found. The duodenal deformity, thought originally to be a pressure defect, was due to a large perforating ulcer invading the liver.

The third patient had an hour-glass stomach and very large lesser curvature ulcer with uremia and cachexia. The condition, at first thought to be malignant, responded to treatment in the manner of a benign ulcer.

The fourth case was that of a man with "gallbladder pain" without icterus or colic. In view of his general condition and the presence of a calcareous shadow in the plain gallbladder film, a diagnosis of abscess complicating carcinoma of the biliary tract was made. Operation showed pyloric stenosis, for which a gastroenterostomy was done. The patient died and at necropsy a solitary gallstone was found, with gross enlargement of the gallbladder and perforation into the stomach.

LEWIS G. JACOBS, M.D.

Benign Tumors of the Stomach. E. M. Finesilver. Surgery **12**: 216–235, August 1942.

The author reviews 9 cases of benign tumor of the stomach gathered from the records of the New York Hospital from its opening in September 1932 through December 1940. Three of the 9 tumors had already become malignant at the time of operation, leaving a total of 6 which could be classified strictly as benign.

The average age of the 9 patients was 44 years; the youngest patient was 24 and the oldest 58. In the entire group there was only one male. The ratio of benign tumors to roentgenologic examinations of the stomach was 1 to 7,200. The ratio of benign to malignant tumors was 1 to 66.

Malignant change is the gravest complication which may occur in these tumors. Adenomatous polyps and leiomyoma are especially prone to this eventuality. The next most important complication is hemorrhage. Anemia and the presence of occult blood are more frequently found in association with this condition than with ulcer of the stomach. Severe bleeding, with hematemesis and melena, while it may occur, is not characteristic of benign gastric polypi, but moderate bleeding, with gross or occult blood in the stool, is quite common. Anemia is usually of the secondary or microcytic type, but in long-standing cases it may progress until it is suggestive of the primary type.

Benign tumors of the stomach do not, as a rule, cause striking symptoms unless they are complicated by bleeding or intermittent obstruction of the pylorus, or unless, because of their size and extent, they interfere with gastric motility and secretion. In a patient with anemia and achylia gastrica, in whom x-ray examination reveals the characteristic punched-out smooth defect in the stomach or first portion of the duodenum, the diagnosis of benign tumor of the stomach is certain. Absence of free hydrochloric acid in the gastric contents was a constant finding in the author's series. Pyloric obstruction, usually intermittent, occurs in a small percentage of cases, the tumor being of the ball-valve type attached to the posterior wall of the stomach and having a long mucous membrane pedicle. Such tumors first obstruct the pylorus in the manner of a ball-valve and finally prolapse into the duodenum.

The differentiation of benign tumors from malignant growths and inflammatory lesions cannot always be made unquestionably by means of x-ray, but certain observations are helpful. Benign tumors produce a filling defect that is circumscribed and punched out in appearance; the filling defect is usually on the gastric wall, leaving the curvature regular and pliant. In inflammatory and malignant lesions, the rugae are obliterated in the immediate area of the tumor, but the rugae surrounding a benign tumor are nearly normal in their arrangement and distribution. Benign tumors cause little or no disturbance in peristalsis and retention is uncommon, except when the lesion is at or near the pylorus. They do not reveal a niche, nor is there any incisura or other evidence of spasm. They are rarely sufficiently large to be palpated. If a polypoid tumor prolapses into the duodenum, it will produce a central translucence in the bulbar shadow which is typical.

Benign tumors may arise from any of the several coats of the stomach and, according to the tissue of origin, may be either epithelial or mesenchymal. In the epithelial group are the adenomas, adenopapillomas, adenomyomas and fibro-adenomyomas, fibromas, lipomas, and the rare angiomas and osteomas. Leiomyomas are the most common of the benign tumors.

In the majority of cases of benign tumor of the stomach, local excision, rather than resection, is indicated.

J. E. WHITELEATHER, M.D.

Cecal Invagination in Regional Enteritis (Terminal Ileitis). G. Rieben. Schweiz. med. Wchnschr. **72:** 914–916, Aug. 22, 1942.

While the cause of regional enteritis is questionable, the clinical course is well known. The author reports this case because he can find no parallel in the literature.

A 30-year-old man had signs and symptoms leading to a diagnosis of acute appendicitis. At operation an intussusception of the cecum was found, 12 cm. long. The cecum and 15 cm. of ileum were red and thickened but showed no signs of obstruction. An appendectomy and cecopexy were done. After operation study of the ileocecal region by x-ray showed some changes in the mucosal pattern but no obstruction. The patient had remained well for the period of observation, one year.

The author questions the necessity of resection in cases of regional enteritis without obstruction, especially as it can carry no guarantee against recurrence.

LEWIS G. JACOBS, M.D.

SUBPHRENIC ABSCESS

Diagnostic Criteria for Subphrenic Abscess Based Upon a Study of 139 Cases. Lew A. Hochberg. Ann. Int. Med. **17:** 183–205, August 1942.

The subphrenic space may become infected through any of six routes: (1) by direct extension from the peritoneum and contiguous organs—liver, stomach, duodenum, kidney, gallbladder, spleen, pancreas, biliary ducts, the lower dorsal or upper lumbar vertebrae, etc.; (2) by distant extension—from an appendiceal infection, a pelvic infection, diverticulitis of the colon, infection about the urinary bladder, an infection of the skin on the upper part of the abdomen or lower part of the thorax; (3) by rupture into the subphrenic area—abscess of the liver, ulceration of the cardio-esophageal region, hydatid disease of the liver, osteomyelitis of the vertebrae or ribs, thoracic empyema; (4) by retrograde lymphatic extension—from thoracic empyema, pneumonia, lung abscess, mediastinitis, etc.; (5) by direct implantation or injury to an anatomically related organ following a penetrating injury; (6) by metastatic infection, as in cases of furunculosis, septicemia, influenza, and osteomyelitis. Of the 139 cases of subphrenic abscess upon which the present paper is based 44 were due to primary disease of the liver and biliary passages, 29 to appendiceal lesions, 9 to renal disease, and 8 to disease of the stomach and duodenum.

Subphrenic abscesses are characterized clinically by a combination of abdominal, thoracic, and costovertebral or lumbar manifestations, any one of which may predominate and at times mask the other symptoms. Roentgen studies are indispensable for early diagnosis. Chest roentgenograms should be taken in all directions, with the patient erect, prone, and in the Trendelenburg position, and during inspiration and expiration. These will show an elevated motionless diaphragm, obliteration of the costophrenic angle, some fluid in the thorax, rotation of the heart to the opposite side, and distortion of the cardiac contour. Basilar pneumonitis may also be seen in such cases. In the later stages there are general retraction and opacity of the affected side. Beneath the diaphragm on the affected side there is often seen a dense shadow

or a gas bubble with a distinct fluid level below. In the advanced case the subdiaphragmatic opacity may extend well below the liver as a homogeneous shadow. Frequently only a few of these findings will be present; they are sufficient, however, to make one highly suspicious of a subphrenic collection of pus. In such instances the diagnosis may be further facilitated by a pneumoperitoneum.

Roentgenographic studies of the lumbar spine and the surrounding area are often of additional aid in the early recognition of these infections. The most frequent finding is obliteration (partial or complete) of the psoas muscle shadow on the affected side. There may also be noted a scoliosis of the spine with the concavity toward the side of the abscess and an approximation of the lower ribs and iliac crest on that side. The liver and kidney may be depressed and the liver edge may lose its sharp contour. In left-sided cases, in addition to the findings noted above, roentgenograms taken in the erect position show a downward displacement of the stomach bubble with an opacity between it and the cusp of the diaphragm.

The complications of subphrenic abscess may lead to serious consequences. They are grouped under three headings: (1) systemic complications, namely, sepsis, prostration, anemia, and cachexia; (2) abdominal complications, including (*a*) local enlargement of the abscess producing pressure upon the surrounding structures and impairment of function, (*b*) rupture of the abscess into the extraperitoneal space, producing a spreading retroperitoneal infection, (*c*) rupture of the abscess through the surgical wound or through the skin, (*d*) rupture of the abscess into the peritoneal cavity, producing peritonitis, and (*e*) rupture of the abscess into one of the hollow viscera; (3) thoracic complications, consisting of (*a*) pleural effusion, (*b*) empyema, (*c*) bronchopleural fistula, (*d*) abscess of the lung, (*e*) pneumonitis or pneumonia, (*f*) pericarditis, (*g*) mediastinal abscess or mediastinitis, (*h*) pneumothorax or pyopneumothorax, (*i*) perforation of the diaphragm, and (*j*) pulmonary embolism. Thoracic complications are usually attributable to neglect or oversight of the primary cause of the abscess, failure to make an early diagnosis, inadequate surgical care even though an early diagnosis has been made, rapid spread of the subdiaphragmatic infection, failure on the part of the patient to consult a physician until complications are present.

Prognosis must be guarded but is more favorable in early uncomplicated cases treated adequately. The mortality is greatest in those cases in which pulmonary complications develop. In the presence of intrathoracic complications the mortality in the group of cases presented in this study was 35 per cent, a total of 27 deaths.

In conclusion, the author emphasizes the fact that early recognition of this condition requires knowledge of the course of the preceding illness, a carefully conducted physical examination, and a series of well taken roentgenograms. J. A. L. McCullough, M.D.

THE SKELETAL SYSTEM

The Skeleton at Birth. J. F. Brailsford. Brit. J. Radiol. **15:** 213–223, August 1942.

The only constantly ossified epiphyseal nuclei at birth are those at the lower end of the femora. Occasionally one is seen at the upper end of the tibia and the upper end of the humerus. The diaphyses are uniformly ossified throughout the skeleton. Nuclei of the os calcis and astragalus are large and begin to show the shape of the bones. A small nucleus for the os magnum may be the only one visible at the wrist. The nucleus of the body of the hyoid and the pair for the greater horns are visible. There is an ossicle representing the manubrium and four separate ones represent the sternum.

The skull shows a large cranium and small facial bones. The vault is represented by a uniform line broken by the fontanelles and at the junction of the supra-orbital and condylar elements of the occipital bone. The basilar segment and the petromastoid appear as dense, somewhat quadrilateral masses. The maxillary antrum is about a quarter of an inch in diameter. The two sides of the mandible have not united.

In the anteroposterior view the spine shows its greatest width in the cervical and upper sacral segments. The vertebral bodies are ovoid in shape with a slight notch in the superior and inferior borders. They increase in size from the third cervical to the fourth lumbar. The transverse processes in the dorsal area are better developed than elsewhere. The lamina in the dorsolumbar area are not fused. In the lateral views, the bodies appear smaller in proportion than the neural arches. There are two general curvatures, a concavity forward in the dorsal and lumbar area, with a sharp angle at the sacral junction, and a concavity forward again in the sacrum.

The sacrum is represented by five separate bodies. The three elements of the innominate bones are ununited.

Premature infants show a diminished ossification corresponding to the stage of development.

A table is given showing the ages at which various bones and ossification centers appear. Many of these can be made out *in utero*, enabling an accurate estimation of the age of the fetus. In multiple pregnancies this information is often valuable in determining death of one fetus. The rate of development of the female fetus is slightly faster than of the male, but this is not sufficiently reliable to permit accurate prediction of the sex. It is sometimes possible to recognize fetal structures in the eighth or ninth week, but failure to visualize is not significant.

Osteogenesis imperfecta may be diagnosed *in utero* near term. Fetal death may be diagnosed by overlapping of the cranial bones. Fetus papyraceus is usually found in twin pregnancy. Serial films may show its development.

The appearance of a lithopedion will depend upon the age of the fetus at death and the interval that has elapsed before roentgenography. There may be an associated normal intrauterine pregnancy.

Signs of fetal injury may sometimes be seen after trauma to the mother. Compressed fracture of the fetal skull is the most easily recognized.

Twins are a common cause of hydramnios. In single pregnancies with hydramnios skeletal anomalies are often demonstrable.

Gross anomalies to be looked for in the fetus are anencephaly, hydrocephaly, meningocele, myelocele and exomphalus. Anencephaly is readily recognized by the absence of the cranial structures. Complete myelocele is not unusual with anencephaly. It is

associated with irregular development of the vertebral bodies and ribs, with dwarfing and fusion of the cervical portion. Localized myelocele is recognized by an abnormal posterior bowing of the spine, forming a characteristic hump. Hydrocephalus is indicated by the enlarged cranium and lack of ossification. This should not be confused with the enlarged appearance of a head in breech presentation due to distortion. In lacunar skull the irregular calcification of the cranium may be demonstrable. Exomphalus is characterized by marked scoliosis of the fetal spine, with unusual shortening of the trunk.

In fetal hydrops the fetus appears to be pushed against the wall of the uterus and the main contents of the organ appear as a soft-tissue mass.

Congenital defects in the extremities may be recognized, as well as dystrophies and Albers-Schönberg's disease.

Birth injuries usually show massive callus. They are most common in the femur, humerus, and clavicle. Injury to the shoulder and brachial plexus may occur during delivery without bony injury.

Roentgenograms are reproduced showing normal and abnormal findings. SYDNEY J. HAWLEY, M.D.

Practical Method of Predicting the Growth of the Femur and Tibia in the Child. G. G. Gill and L. C. Abbott. Arch. Surg. **45:** 286–315, August 1942.

Modern orthopedic procedure involved in operations to change the relative length of the legs makes it desirable to have an accurate estimate of the probable future growth of the normal and abnormal extremities. Since for various reasons previous methods have not been entirely satisfactory, the authors use the following procedure:

1. The child's height is measured as he stands on the normal leg with the pelvis level.
2. The age is recorded in years and months. This is checked against the skeletal maturation age obtained from Todd's *Atlas of Skeletal Maturation* (St. Louis, C. V. Mosby Co., 1937). If the skeletal maturation is more than six months advanced or retarded from the chronologic age, the skeletal age is substituted for the chronologic age in all further calculations.
3. From the sex, the height, and the corrected age, the person is placed in his or her percentile position of the percentile chart [An illustration shows curves of percentile distribution of height constructed from tables for percentile distribution of stature given by the White House Conference on Child Health and Protection, 1932, and includes subtables (compiled from different data) showing additions to percentage of stature of femur and tibia at various ages to determine their probable final percentages of adult stature.] By following up the chart between the parallel percentile curves to the completion of growth, the expected final stature of the person is obtained. In boys, growth is complete at the age of 18 1/2 years; in girls, at the age of 16 1/2.
4. The lengths of the femur and the tibia are measured from teleroentgenograms or slit scanograms.
5. The present percentage of the normal femur to the stature is obtained by dividing its length by the present height and multiplying by 100. The same calculation is carried out for the tibia.
6. To the percentages calculated under 5, are added the amounts, either positive or negative, given in the subtables referred to above, according to the sex, the corrected age, and the bone. This gives the estimated adult percentages of these bones to stature.
7. These percentages are then multiplied by the predicted stature to give the expected final length of each bone.
8. By subtracting the present length of the normal femur from the expected final length of the normal femur, the expected growth of this bone is obtained. The expected growth of the normal tibia is obtained in the same manner.
9. Growth from the distal part of the femur equals expected femoral growth × 70 per cent. Growth from the proximal part of the tibia equals expected tibial growth × 55 per cent. Growth from the distal part of the tibia equals expected tibial growth × 45 per cent.

Predictions by this method are highly accurate; the maximum single error observed was 2 1/2 inches, and the average error 1/2 inch.

The percentage of growth to be expected from the proximal and distal epiphyses was estimated by use of vitallium markers implanted in the bones of 3 patients. The estimates arrived at are for the femur, 30 per cent proximal end and 70 per cent distal end; for the tibia, 55 per cent proximal and 45 per cent distal end. The estimation of the probable growth of the abnormal limb involves three factors: (1) disturbances confined to specific epiphyses, (2) disturbances involving all epiphyses, and (3) mechanical loss of length. Consideration of these factors in conjunction with the preceding facts will indicate the approximate growth to be expected.

LEWIS G. JACOBS, M.D.

Fibrous Dysplasia of Bone: A Condition Affecting One, Several, or Many Bones, the Graver Cases of Which May Present Abnormal Pigmentation of Skin, Premature Sexual Development, Hyperthyroidism, or Still Other Extraskeletal Abnormalities. L. Lichtenstein and H. L. Jaffe. Arch. Path. **33:** 777–816, June 1942.

This paper is based on 23 cases of polyostotic fibrous dysplasia studied clinically, roentgenographically, and histologically, and on 67 cases collected from the literature. The authors regard the condition as a congenital developmental anomaly. The skeletal lesions are variable in extent and severity; extraskeletal manifestations are seen chiefly in association with severe bone involvement and include pigmentation of the skin, endocrine dysfunction, and premature skeletal growth and maturation. When more than one bone is affected the involvement tends to be wholly or predominantly unilateral.

The skeletal lesions, which are considered by the authors as adequate for clear delimitation of the condition, are described by them as follows. "In an affected bone, the area implicated may be found expanded in part or throughout. Where it is not expanded, the regional cortex is likely to show at least erosion and thinning from the medullary side. The interior of the involved area is found to be filled mainly by an evenly whitish or reddishly speckled rubbery and compressible tissue. Fundamentally, this is fibrous connective tissue. It may be gritty throughout from the presence everywhere in it of newly formed trabeculae of immature bone. Or, instead, it may show some smaller or larger, non-gritty, highly col-

lagenous areas in which few if any bone trabeculae are to be seen. In some lesions, islands of hyaline cartilage may also be present within the fibrous connective tissue. Furthermore, in an occasional lesion, focal degeneration of this tissue may have led to the formation of small secondary cysts."

Clinically the cases are classified according to the extent of the disease. Monostotic involvement is comparatively common. It was seen in 9 of the authors' patients. Such cases are often difficult to diagnose roentgenographically. The picture varies from case to case and may be interpreted as a bone cyst, enchondroma, or perhaps a giant-cell tumor. Even a biopsy may not be conclusive.

When several—or many—bones are involved, roentgen diagnosis is less difficult for, though the appearance presented by any single area of involvement may not be distinctive, the multiplicity of the lesions should suggest the nature of the condition.

An individual bone considerably involved in fibrous dysplasia presents roentgenographically a number of discrete rarefactions, or, if the latter have become confluent, the major part of the bone may appear more or less diffusely rarefied. The rarefactions reflect the replacement, in the affected area, of the spongy bone and of the adjacent inner surface of the cortex by fibrous connective tissue, which, of course, is relatively radiolucent. If within this tissue there has been substantial metaplastic ossification, the rarefaction shadow is likely to present a mottled or rather cloudy ground-glass appearance. The latter expresses the character of the immature new bone. In some lesions one may even note stippling here and there, indicating the presence of islands of ossifying cartilage. On the other hand, in areas in which the fibrous tissue filling the interior of the bone is not undergoing appreciable metaplastic ossification and in which there are no islands of cartilage undergoing ossification, the rarefaction shadow resembles that which would be cast by a cyst.

The cortex in the affected area is usually found thinned and may even have been reduced to a mere shell in consequence of erosion of its endosteal surface by the dysplastic fibrous tissue. Except in the region of a fracture, the outer surface of the thinned cortex shows no periosteal new bone apposition. Indeed, any new, re-enforcing periosteal bone being laid down is deposited so slowly that roentgenographic evidence of it is generally lacking. On the other hand, there is no appreciable resorption of the outer surface of the cortex, and there is never any evidence of scalloped erosion beneath the periosteum, as seen in hyperparathyroidism.

At the site of a recent pathologic fracture one generally sees considerable cortical thickening, resulting from organized callus. Old infraction lines stand out as relatively opaque linear markings, usually more or less at right angles to the cortex. Affected flat bones, in particular, may present a "trabeculated" appearance, but actually this merely reflects the presence of short bony spurs and low ridges on the endosteal contour of the thin, eroded cortex.

Skin pigmentation is mentioned as occurring in about a third of the 90 cases furnishing the basis of this report. Premature sexual development appears to be limited to females. Of 51 female patients, 20 showed pubertas praecox. This figure is undoubtedly high, however, as these cases are probably more frequently recorded than those not so complicated. Hyperthyroidism was present in some of the younger patients, both male and female. Premature skeletal growth and maturation have occasionally been observed in girls. The occurrence of other developmental defects, occasionally recorded, lends support to the opinion that fibrous dysplasia in its severe form is an expression of a deeply rooted defect of development, in which the basic clinical picture, represented by the skeletal changes, is amplified by various extraskeletal abnormalities.

Treatment is governed by the extent of the disease. It includes such measures as curettage in single lesions, with filling of the cavity by bone chips; autogenous bone grafts, and the use of such mechanical aids as corrective shoes, braces, etc. Except in the very severe cases, with extraskeletal abnormalities, the expectancy of life is not reduced. Malignant change has not been observed.

Osteochondritis Deformans of the Hip (Legg-Perthes Disease) and Renal Osteitis Fibrosa Cystica. Report of a Case with Anatomic Studies. E. A. Gall and G. A. Bennett. Arch. Path. **33:** 866–878, June 1942.

A full necropsy report is given of a case of bilateral Legg-Perthes disease associated with renal osteitis fibrosa cystica, in a boy of thirteen. Histologic study of one hip showed massive bone and marrow necrosis of the femoral capital epiphysis, producing severe deformity of the joint but causing little damage to the articular cartilage. It seemed probable, though it could not be proved, that these changes were the result of interference with the blood supply. Ordinarily, with the occurrence of physiologic fusion and disruption of the epiphyseal cartilage, vascular channels from the shaft marrow enter the involved area and repair and reossification occur, though the deformity remains. In this case death intervened before fusion occurred. The associated skeletal changes were believed to bear no relation to the deforming hip lesion but to have been of renal origin. The right kidney was missing and the left was severely altered as a result of chronic pyelonephritis. The parathyroids were enlarged.

New Approach to the Diagnosis of Herniation of the Intervertebral Disc. W. Duncan and T. I. Hoen. Surg., Gynec. & Obstet. **75:** 257–267, August 1942.

The authors' new approach to the diagnosis of herniation of the intervertebral disc is based on a study of the alteration in both the attitude of the lower spine and mobility of the intervertebral joints.

The anatomy and pathological degenerative changes within the discs are reviewed briefly. It is pointed out that the patient with a herniated intervertebral disc really suffers from two lesions: a traumatic neuritis of the involved root or roots and a diseased intervertebral joint. The neurological manifestations are much more obvious than the altered mechanism of the joint and have received disproportionate attention.

The pain or paresthesia is proportional to the force of the herniation on the involved root or roots. In order to relieve this pain, the patient assumes the most comfortable position, a tilting away from the

diseased side. Since the extruding mass lies posteriorly, an attitude of forward flexion will also be assumed. The predominance of one or the other is determined by the position of the mass; thus a laterally placed mass produces more tilt than kyphosis. After a time the deformity apparently becomes fixed and is present even during a remission of symptoms. This fixation is believed to be due to the presence of noncompressible cartilaginous sequestra within the diseased joint.

The derangement of the joint is demonstrated in roentgenograms made with the patient standing, views being taken in the lateral, forward, and backward bending positions. In the majority of cases the films demonstrate a lack of spinal mobility localized to the involved joint. This is manifested by little or no resiliency when the spine is bent toward the affected side. It is emphasized that the "bending films" establish the level rather than the presence or absence of the disc protrusion. Postoperative films reveal restoration of joint mobility.

Few of the cases studied showed pronounced narrowing of the intervertebral disc on routine roentgenograms and, when it occurred, it seemed to represent a later stage in the pathological sequence. The most common roentgen finding was widening of the intervertebral space on the affected side, along with slight narrowing of the disc. Myelography by contrast medium was reserved for those cases in which symptoms and mobility suggested the presence of a lesion but did not fix the position. Laterally placed herniations consistently gave normal myelographic findings. Myelography was also used in certain cases to rule out tumor.

Neurological findings are not reliable evidence as to the level of the lesion. Bilateral neurological findings, rectal and vesical disturbances, all suggest mid-line herniation.

A summary of the differential diagnosis is given. Conservative therapy is recommended. Criteria for operation are: (1) pain, relieved by conservative measures; (2) severe fixed spinal deformity; (3) profound neurologic disturbance.

No tabulation of cases or results is presented.

IVAN J. MILLER, M.D.

Osseosonometry: Use of Percussion-Auscultation in Fractures. W. H. McGaw. Arch. Surg. **45:** 195–205, August 1942.

Percussion over one end of a bone will set up audible vibrations that are clearly heard with a stethoscope at the other end. These vibrations are even transmitted through one or more joints. A normal bone gives a low-pitched, resonant, "osteal" note of almost metallic quality. In fractures the change in percussion note gives information of value in advance of the roentgenograms without added expense to the patient; the diagnosis of fracture can be made by this method alone. The presence of a normal, intact bone on the opposite side makes this method especially useful in fracture of the extremities.

The properties of sound are intensity, quality, and pitch. If a bone is struck, it will vibrate at a frequency determined by its size, shape, weight, and elasticity. If it is set in vibration with a tuning fork, the pitch will be that of the fork. A fracture changes the intensity, quality, and fundamental pitch, the intensity being diminished and the quality flat. If the bone is successively percussed along its length, the sound becomes normal on crossing a fracture line to the side nearer the stethoscope (method of Vigevani. See Policlinico, sez. prat., **3:** 1783, 1925). Greenstick fractures produce less change, or none at all, in the sounds; impacted fractures give a normal sound. Healing by soft callus leads to only slight diminution of intensity, with approximately normal quality and pitch. Bony reunion leads to re-establishment of the normal note, or if callus is excessive, to increase in intensity and lowering of pitch. In recent fractures, traction with separation of the bone ends ("overpulling") can be diagnosed by loss of the percussion sound.

For fractures of the tibia, the stethoscope is best placed on the tibia at the knee; for fractures of the femur, on the symphysis; for humeral or clavicular fractures, on the manubrium. For research purposes, a crystal pick-up with vacuum tube amplifier, loud speaker, and cathode ray oscillograph were used, but for clinical use a stethoscope is as good as this more complex apparatus.

LEWIS G. JACOBS, M.D.

Fractures of the Os Calcis. J. O. Dieterle. Wisconsin M. J. **41:** 662–666, August 1942.

Most fractures of the os calcis represent one of four types: (1) linear fractures of the tuberosity or body with no widening or displacement of bone; (2) compression fractures with comminution and lessening of the salient angle; (3) comminuted or compression fractures of the anterior portion involving the calcaneocuboid joint; (4) compound fractures.

The salient angle should be determined in every instance from a lateral roentgenogram. It is formed by the intersection of two lines projected on the upper edges of the superior processes, the normal angle being between 35 and 40 degrees. Any appreciable decrease in this angle indicates gross displacement of fragments and treatment cannot be considered adequate unless an attempt is made to restore the proper relationship.

In heel injuries it is important that roentgenograms include views of the foot in anteroposterior and oblique directions from the sole, as these views will reveal fractures of the anterior portion of the os calcis that might otherwise be missed.

The management of the various forms of os calcis fractures is discussed briefly. Among the common errors which are cited are omission of lateral, oblique, and anteroposterior roentgenograms of the foot and omission of roentgenograms of both heels.

L. W. PAUL, M.D.

March Fracture: A Report of 15 Cases. A. B. Sirbu and A. M. Palmer. California & West. Med. **57:** 123–127, August 1942.

Fifteen cases of march fracture seen within eighteen months are reported by the orthopedic surgeons of Fort Ord Station Hospital. These represent 25 per cent of all metatarsal fractures (60) and 2 per cent of all fractures (618) seen in the same period.

Theories as to the etiology of march fracture are briefly reviewed. The authors are of the opinion that it is a stress fracture secondary to a developmental anomaly. The second metatarsal bone was involved in 7 cases and the third in 8. X-ray studies in all the

cases showed a short first metatarsal. The sesamoids, being even more proximally located, produce an additional shortening effect. The weight balance is thus shifted from the first to the second and third metatarsal bones. These bones are long and slender and their bases are relatively fixed, so that as stress is transmitted to the shaft, fracture may result.

Morton (Am. J. Surg. **9:** 315, 1930) states that in the evolution of the human foot the first metatarsal gradually grows to parallel the other metatarsals, loses its mobility, and increases in length. The authors are not in full accord with this view. They attribute this illusion of increased length to the relative size of the phalanges. Actually, the first metatarsal has been found to be longer than the other metatarsals in only 30 per cent of those examined, equal to the second in 10 per cent, and shorter in 52 per cent. It is possible, as reported in the German literature, that energetic rhythmical cadence may be a factor in march fracture. Among Italian soldiers, whose gait is less rigid than that in the German army, far fewer fractures of this type are reported.

All the men in the authors' series were originally from civilian life and attached to field or tactical units calling for long marches and frequent drilling. The average age was 23.7 years. In most of these cases (70 per cent) there was no specific history of trauma. In one case the roentgenograms suggested an Ewing's sarcoma. Eventual disappearance of symptoms and consolidation of callus after the patient was confined to bed helped to determine the correct diagnosis.

Treatment calls for bed rest, application of a metatarsal pad, and strapping to relieve weight bearing, with such supplementary measures as an anterior heel or metatarsal bar to the shoe, local heat, light massage, and exercise to tone up the foot muscles. In the army length of disability is longer than in civilian life because the soldier must be hospitalized until he is fit for active duty. In this series, the period of disability averaged twenty-one days.

MAURICE D. SACHS, M.D.

GENITO-URINARY TRACT

Primary Carcinoma of the Ureter. L. E. McCrea. Urol. & Cutan. Rev. **46:** 485–490, August 1942.

One hundred and sixty-one cases of primary carcinoma of the ureter are said to have been reported in the past 100 years. The author contributes 2 additional cases. A prominent and primary symptom in each was intermittent hematuria followed by acute urinary retention.

A study of the cases appearing in the literature shows the incidence to be chiefly in the fifth and sixth decades. Hematuria, both gross and microscopic, was present in 75 per cent of the cases. Gross hematuria appeared intermittently as a gentle, continuous flow. Pain occurred in 65 per cent of the cases, usually localized in the costovertebral area. The right side and lower third of the ureter were more frequently involved. Loss of weight, nausea, and vomiting were late symptoms. Dysuria, frequency of urination, and nocturia were in direct proportion to the inflammation of the vesical mucosa.

Cystoscopy and roentgen studies usually determine the diagnosis of ureteral tumor. Cystoscopic evidence of a papillary tumor projecting from the ureteral orifice, of a tumor implant close to the orifice, or a combination of both, is a prime diagnostic factor. Persistent copious bleeding from the orifice following intraureteral manipulation is frequently seen. Roentgen studies may not always disclose such salient features as hydronephrosis or tumefaction within a distended ureter. Intravenous pyelography may be of value in revealing a non-functioning kidney. Urinalysis is of great help, as microscopic evidence of detached papillomatous villi may be obtained.

In most instances pathologic studies have shown the tumor to be a papillary carcinoma. Several cases of squamous-cell carcinoma and one sarcoma are recorded.

Radical surgical removal of the ureter with its tumor, as well as the involved portion of the bladder, is the method of choice. If the kidney is involved, by secondary infection, its removal is recommended. Results with radiation therapy have not warranted its routine use alone.

MAURICE D. SACHS, M.D.

THE VASCULAR SYSTEM

Application of Phlebography to the Therapy of Thrombosis and Embolism. C. E. Welch, H. H. Faxon, and C. E. McGahey. Surgery **12:** 163–183, August 1942.

Increasing clinical interest in the problems of thrombosis and embolism has led to the frequent use of phlebograms, not only for diagnosis, but in many cases to furnish necessary preoperative information. An accurate phlebogram should demonstrate, so far as possible, the patency or blocking of all parts of the venous system of the extremity.

Several different methods have been used. The simplest is that proposed by Linton (in a personal communication to the authors), which calls for injection of the contrast medium into one of the dorsal veins of the foot, or the distal end of the long saphenous vein. Return of blood through the long saphenous vein is prevented by application of a blood pressure cuff, with a pressure of 20 mm. mercury, with the upper level at the mid-calf. Prompt filling, primarily of the posterior tibial vein by means of numerous perforating branches in the lower leg, is thus obtained. This method has produced phlebograms that are as accurate as those obtained with the more cumbersome procedure described by Bauer (Suppl. 61, Acta. chir. scandinav., 1940) and summarized in the present paper.

All methods are subject to certain theoretical objections. A phlebogram cannot be considered absolutely reliable in so far as the diagnosis of thrombosis is concerned. Occasionally the presence of thrombosis will be demonstrated when the leg appears clinically normal. On the other hand, the failure to demonstrate obstruction should not be considered as an indication of the absence of thrombosis when the clinical signs are present.

In general, phlebograms are valuable in any case of known or suspected thrombosis of the veins of the lower leg and after the occurrence of a pulmonary infarct, unless it unquestionably has arisen from elsewhere than the leg. Phlebograms on each leg may be done without risk to the patient. There has been no indication of systemic manifestations following the injection of 50 c.c. of diodrast; nor has there been

any evidence of the mechanical dislodgement of thrombi or of irritation sufficient to produce a venous thrombosis.

The phlebogram, to be considered of value, must furnish information that is not demonstrable by astute clinical examination. Certain groups of cases, of which the authors present examples, demonstrate its value most clearly. These are, particularly:

(1) Those in which a diagnosis of thrombosis is important, even though no specific therapy is contemplated.

(2) Cases of pulmonary infarction, with no evidence of the source. Phlebograms of the legs may show the source of the emboli, and ligation of the femoral vein will result in cure.

(3) Acute superficial thrombophlebitis. Frequently an associated widespread thrombosis of the deep venous system will be found.

(4) Cases in which the presence of a deep thrombosis is suspected and immediate therapy is contemplated. The early detection of thrombosis is essential if treatment is to be instituted before emboli have occurred. Hence, phlebograms are performed as emergency procedures on the slightest indication. Many types of pictures are obtained. (*a*) There may be massive thrombosis of all main deep venous channels. In the usual case, practically no veins are visible on the x-ray plate. (*b*) Thrombosis of the veins of the calf may be found. One or all of these vessels may be thrombosed. If all are thrombosed, interpretation is easy, but if only a single vein is not filled, the radiographic interpretation is likely to vary with different observers. A phlebogram of the opposite leg is especially valuable as a control. (*c*) The popliteal and lower femoral veins may be partially thrombosed. This is a stage intermediate between (*b*) and (*a*). (*d*) Occasionally, the entire femorocrural system will not be found to be thrombosed, but mural thrombi involving only a portion of the femoral vein will be observed.

The therapy of venous thrombosis is considered only briefly. The authors say: "In our clinic we have attempted to evaluate venous ligations, chiefly because our incidence of emboli has been high. Thus, our control group showed one infarct out of every three cases of deep phlebitis, while the death rate of thrombophlebitis in patients over the age of 50 was nearly 8 per cent because of massive infarcts alone. The mechanical prevention of emboli by actual ligation was, therefore, especially appealing.

"We have now ligated 82 femoral veins for deep venous thrombosis. Ligation is done in any case if the patient is 40 years of age or over, or if he is under 40 and has a bland thrombosis or has had a pulmonary infarct. Of the patients in the ligated group, the average age was 56. . . . . After ligation we observed only two infarcts, one of which could not be confirmed by x-ray, and neither one of which was fatal. Bilateral ligations have been done 9 times. The site of ligation is very important and may be determined by the phlebogram."

J. E. WHITELEATHER, M.D.

RADIOTHERAPY

MALIGNANT TUMORS

Results of Treatment in Carcinoma of the Cervix. J. H. Müller. Schweiz. med. Wchnschr. **72:** 909–910, Aug. 22, 1942.

To the usual 4 stages of cervical cancer, the author adds a 5th stage, which he terms stage 0, to cover the typical "early case," usually found by colposcopy or Schiller's iodine test. Of 137 patients seen between 1933 and 1936, 5 were in stage 0, 36 in stage I, 64 in stage II, 24 in stage III, and 8 in stage IV. All the cases in stage 0 were treated by total abdominal hysterectomy only. Of the stage I patients, 20 were treated by irradiation, 12 by operation and irradiation, and 2 by operation only. In stage II, 62 patients were treated by irradiation only, 2 by operation followed by irradiation. Stage III and IV cases were treated with irradiation only. Seven patients were not treated; in 5 cases the patient was in too poor condition and in the other 2 (both stage I cases) treatment was refused.

The absolute five-year cure rate was 80 per cent for stage 0 (one patient died of postoperative complications), 69.4 per cent for stage I, 34.4 per cent for stage II, 8.3 per cent for stage III, and none for stage IV. The total five-year cures were 38.7 per cent of the 137 cases, or 40.8 per cent if the 7 untreated cases are eliminated. Of those dead before five years, 10 died of intercurrent disease with no evidence of recurrence. The prognosis was found to be about the same in young as in elderly patients.

The author advocates operative treatment in stage 0 whenever possible for the sake of preserving ovarian function and avoiding the menopausal syndrome.

LEWIS G. JACOBS, M.D.

Primary Carcinoma of the Fallopian Tube: Case Report. J. E. Hobbs. South. M. J. **35:** 733–737, August 1942.

Less than 400 authentic cases of primary carcinoma of the fallopian tube have been reported in the literature through 1940. A case is here added in which a correct preoperative diagnosis was made on the basis of a pelvic mass and a serosanguineous discharge. Carcinoma of the uterine fundus was excluded by diagnostic curettage. The involved tube and the ovary on that side were removed and postoperative roentgen therapy—a total of 1,200 r to each of four portals—was given, followed by intra-uterine radium application for a total dosage of 4,052 mg. hr. At the time of the report, a few months later, the patient was in good condition.

The usual accepted treatment for carcinoma of the tube—total hysterectomy, bilateral salpingo-oophorectomy, and in some cases deep roentgen therapy—gives poor results. Less than 5 per cent five-year cures are reported. The author suggests a modified therapeutic procedure. First, the patient is curetted and if carcinoma is found, whether endometrial or tubal, a complete four-port pelvic cycle of deep roentgen therapy is administered, followed four weeks after completion by intra-uterine radium application (4,000

to 5,000 mg. hr.). After six weeks a complete hystero-salpingo-oophorectomy is done. The cervix is closed tightly. The fimbriated ends of the tubes are ligated before any manipulation is carried out.

If cancer is not found by curettage and tubal cancer is suspected or discovered inadvertently, a bilateral adnexectomy and fundectomy should be done. The remainder of the uterus and cervix serves as a container for the subsequent implantation of radium. The tubes are ligated close to the uterus to prevent uterine implants. The patient is then given deep therapy, followed by radium, as described. This method combines the benefit of surgical removal and adequate radiation. The additional radium therapy may improve the unfavorable mortality rate in primary carcinoma of the fallopian tube.

MAX MASS, M.D.

Factors Influencing the End-Results in Carcinoma of the Ovary. Report of a Series of 138 Patients Treated from 1910 to 1935. H. C. Taylor, Jr., and A. V. Greeley. Surg., Gynec. & Obst. **74:** 928–934, May 1942.

Four principal factors influence the end-results in any series of ovarian carcinomas: the gross extent of the disease, the histologic type of tumor, the histologic grade of tumor, and the use of radiation. With these in mind, Taylor and Greeley have reviewed a series of 138 cases showing an absolute five-year cure rate of 15.2 per cent. The most significant factor in this series was the gross stage of the tumor at the time of operation. Known five-year cures in the operable group, *i.e.*, those in which all the cancer was apparently removed, amounted to 45.5 per cent; with partial removal there were only 4 per cent cures, and in recurrent cases or those in which exploration only could be done there were none.

In relation to the histologic types of tumor the authors point out the necessity, in reporting statistical series, of designating these, since in some the prognosis is relatively favorable in comparison with the others. The present series included 63 papillary serous adenocarcinomas with 14.3 per cent five-year cures, 25 pseudomucinous adenocarcinomas, with 20 per cent five-year cures, and 16 granulosa-cell tumors with 31.3 per cent five-year cures.

The histologic grade of the tumor was found to play an important role in determining the end-result in the sense that the differentiated tumors of perhaps doubtful malignancy had a very much better prognosis than the others. Thus in the adenocarcinoma group there were 12 cures among 36 differentiated tumors, but only 2 among 52 cases lacking differentiation.

Postoperative x-ray therapy was apparently responsible for the five-year cure of 2 cases in which recurrence was otherwise certain, but the effect of x-ray on the percentage of five-year cures and on survival curves was less than has been frequently claimed.

Has a Real Increase in Lung Cancer Been Proved? Madge T. Macklin. Ann. Int. Med. **17:** 308–324, August 1942.

In this paper the author discusses the methods used to determine the alleged increase in the incidence of pulmonary cancer and points out the fallacies involved. Three methods are taken up—determination of the ratio of lung cancer autopsies to total autopsies, determination of the ratio of lung cancer autopsies to all cancer autopsies, and the study of hospital admissions as a basis of comparison. Among the fallacies mentioned are the failure to take account of sex and age distribution; failure, in comparing with total cancer cases, to consider all histologically proved cases, whether proof has been obtained at biopsy, operation, or necropsy; the selected nature of hospital and autopsied cases and their consequent deviation from the general population.

In her conclusions the author says:

"The question we wish to determine is not whether lung cancer, meaning by that diagnosed lung cancer is increasing in hospital cases, but is diagnosed lung cancer increasing in the population of the age and sex distribution which is capable of showing it? Therefore, the only way of determining this point is to study the incidence of diagnosed lung cancer in the population at large, and not in the small fragment of the population which comes to autopsy. Therefore, data from all hospitals within a state for two periods chosen so that the age and sex distribution of the population of the state is known, thus preferably in a census year, should be added together and analyzed. Cities are not large enough in their scope, since they draw obscure cases from surrounding rural areas in different proportions in various years. Each state, however, has usually centers that are apt to draw patients from within its own borders.

"It will probably be found that diagnosed lung cancer is increasing both relatively and absolutely, but the increase will probably be much smaller by this method than by the ones adopted by most workers, in which age and sex distribution of the lung cancer cases and of the standard group were ignored. Lung cancer will be increasing because it is being diagnosed in more cases in which it exists than was formerly the case, and will be increasing no doubt because persons of lung cancer age are having fewer diseases to die of today than they had before, and hence must die in ever increasing numbers of the ones which remain.

"The data which are used to support the idea that lung cancer has increased faster than other forms of cancer cannot be used to support that conclusion, since we do not know what proportion of lung cancer cases were unrecognized formerly and what proportion are unidentified today. We can merely state that *diagnosed* lung cancer is increasing at a rate which appears to be faster than that of other *diagnosed* cancers."

J. A. L. MCCULLOUGH, M.D.

An Improved Lead Shield for Treatment of Malignant Lesions about the Eyes. Eugene A. Hand. Arch. Dermat. & Syph. **46:** 284, August 1942.

A lead eyecup is generally used for protection of the eyeball in radiation treatment in this area. Difficulty in removing this shield has been experienced by the author where it has been left in position for a long time. To obviate this, he has drilled a small hole in the eyecup just large enough to fit a shortened hypodermic needle. After treatment a small amount of water or saline is injected into the hole. This relieves the potential vacuum between the cup and the eyeball and the shield floats off.

JOSEPH T. DANZER, M.D.

NON-NEOPLASTIC CONDITIONS

Discussion on the Place of Radiotherapy in the Treatment of Thyrotoxicosis. L. Martin and F. Ellis. Proc. Roy. Soc. Med. **35:** 561–568, June 1942.

This discussion includes two separate papers, one by Martin, who refers to a fuller report of his follow-up studies published elsewhere (Quart. J. Med. **11:** 1, 1942), and one by Ellis.

Martin's series comprised 42 cases—31 of primary type, 7 of secondary type (toxic nodular goiter), and 4 of non-toxic goiter. Of the primary cases, 19 or 61 per cent were cured by radiation while 10 showed improvement. Only one of the 7 patients with secondary thyrotoxicosis was cured and she had hypothyroidism; none of those with non-toxic goiter was cured. Martin points out that surgery and irradiation act in the same way, namely, by removal of the thyroid component of the thyrotoxicosis. Thus, in those cases designated as mild primary and border line, treatment is of little effect since, though it removes the thyroid component, it leaves unchanged the associated constitutional nervous instability.

Ellis' series numbered 82 cases: 54 of primary and 28 of secondary thyrotoxicosis. Of the primary cases, 50, and of the secondary, 21, received radiotherapy alone or following surgery. Improvement was obtained in all the primary group, amounting to cure in 37 cases, or 74 per cent. Of the secondary cases 10 were cured (48 per cent), and 6 others improved. Comparing the results and the dangers of radiotherapy and surgery the author concludes that radiation with x-rays (or a radium beam) to the thyroid is the treatment of choice in primary thyrotoxicosis, but that in secondary thyrotoxicosis operation is to be preferred, because, although irradiation may be used to improve such cases, it cannot cure the cardiac irregularity and the delay of more effective measures may allow cardiac degeneration to become worse.

A brief description of the several radiation technics employed is included.

Effect of Therapeutic Doses of X-Ray on Infections and Inflammations. L. A. Weed, A. P. Echternacht, E. J. Meister, and R. Isenhour. Surg., Gynec. & Obst. **75:** 157–160, August 1942.

The authors present experimental data on the effect of x-rays on infections due to *Clostridium welchii*, on the organisms and their toxins, and on the toxins of *Staphylococcus aureus* and *Corynebacterium diphtheriae*.

A killing time of forty-eight hours in standard weight guinea-pigs was established by inoculating the animals with a twenty-four-hour meat culture of *Clostridium welchii*. A series of 12 animals was so inoculated, 6 being used as controls, and the remaining 6 treated with three doses of x-ray two and a half, six and a half, and eleven and a half hours after inoculation. The factors were 140 kv., 5 ma., 1 mm. aluminum filter. Both experimental and control animals died within twenty-four hours; therapy was without effect.

The effect of x-ray on *Clostridium welchii in vitro* was studied by preparing a filtrate of a twenty-four-hour brain broth culture containing the organisms in suspension. Equal samples were irradiated with 500, 1000, 1,500, and 2,000 r. A single control was used. The samples were plated out immediately after treatment and quantitative counts of viable organisms present indicated no effect of the roentgen exposure.

The dermonecrotic toxin produced by *C. welchii* was treated with a single 2,000 r dose of x-ray and injected under the skin of guinea-pigs. The reaction produced was indistinguishable from that produced by untreated toxin. Treating the area of injection with x-ray before inoculation showed no prophylactic effect.

A duplication of the experiments on experimentally produced *C. welchii* infections with a different strain of organisms and using graded doses of the filtrate showed a similar result.

The toxins of *Corynebacterium diphtheriae* and *Staphylococcus aureus* were also subjected to irradiation. Cutaneous tests on experimental animals showed no demonstrable effect.

In the evaluation of their experimental data the authors express the belief that there is no satisfactory experimental support for the widespread clinical impression that x-ray therapy is of benefit in the treatment of gas gangrene. It is pointed out, also, that prophylactic treatment of wounds against gas gangrene is not treatment of the disease itself.

Those interested in the detailed experimental technic should consult the original article.

IVAN J. MILLER, M.D.

Unilateral Roentgen Irradiation in the Treatment of Acne Vulgaris. P. R. Kline, and E. Gahan. Arch. Dermat. & Syph. **46:** 207–210, August 1942.

Roentgen therapy has been used in acne for the past forty years. As early as 1907 Pusey stated that it was the "method of preference." It has been thought by many that the beneficial results obtained are due to atrophy of the sebaceous glands, but numbers of experiments have been conducted which appear to disprove this idea.

The authors selected 50 patients with acne vulgaris of the face and gave 75 r units at weekly intervals to the right side of the face only, for an average of ten treatments. Of the 50 patients 35 completed the experiment. "In 20 patients the untreated side improved as much as the treated; in 9 there was improvement only on the treated side; and in 6 there was no improvement on either side."

From this experiment it is concluded that x-rays not only cause a functional atrophy of the sebaceous glands, but that they also have another effect, the nature of which is still undetermined.

JOSEPH T. DANZER, M.D.

Radiotherapy in the Prophylaxis and Treatment of Keloid. W. M. Levitt and H. Gillies. Lancet **1:** 440–442, April 11, 1942.

The authors have used roentgen therapy in both the prevention and treatment of keloids. For prevention a combination of preoperative and postoperative irradiation has proved most effective. In a series of surgical cases in which keloid might be expected to develop, an erythema dose was given and operation was carried out during the period of active erythema, *i.e.* five to ten days after irradiation, with the result that the incidence of keloid was practically negligible, though occasionally there was some slight thickening at a later stage of healing. This was obviated by a single postoperative treatment. The authors conclude that prophylac-

tic irradiation should be carried out in all cases where (1) the patient is known to have a tendency to keloid formation; (2) when the incision is across the natural skin creases; (3) when an incision has to be made in thick skin; (4) when there has been continued exposure of raw surfaces, as in burns. Contraindications are the presence of sepsis, active tuberculous nodes, and abdominal scars in young women, unless contact therapy is available.

Of developed keloids, those of the red, fleshy type are most responsive to treatment, while white, fibrous thickening is usually completely radioresistant. In general treatments should be limited to two or three in number, with suitable intervals. The dosage varies with the area which has to be exposed and the region of the body. Facial scars are given about 10 per cent lower dosage than scars on the body. The smallest scars, either linear scars or rounded scars up to a few millimeters in diameter, may be given as much as 1500 r at the first exposure, the dose required to produce a well marked erythema. Larger scars, say 1 cm. wide or 2 cm. in diameter for an irregular scar, require about 1000 r, while still greater areas receive 800 to 1000 r, according to size. (No allowance has been made for back-scatter in computing these doses.) There is no difference in the dosage whether contact therapy, medium therapy, or higher-voltage therapy is used. With contact therapy several scars, of large total area may be covered at a single session. With higher voltages, however, it is wise to limit the area treated—to 100 sq. cm. with medium therapy (130–150 kv.) and 50–75 sq. cm. with the highest voltages (200 kv.), except on the abdomen, where these figures should be halved.

The application of roentgen therapy to keloids following war injuries is briefly discussed.